

# NUCLEAR SCIENCE ABSTRACTS

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UNITED STATES ATOMIC ENERGY COMMISSION

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# NUCLEAR SCIENCE ABSTRACTS

Volume 14 Number 17

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## GENERAL AND MISCELLANEOUS

**16491** ANL-6104

Argonne National Lab., Lemont, Ill.

RADIOLOGICAL PHYSICS DIVISION SEMIANNUAL REPORT [FOR] JULY THROUGH DECEMBER 1959. 128p. Contract W-31-109-eng-38. OTS.

An investigation of the emission spectrum from radiation-damaged xylene led to the conclusion that no gross corrections are needed for xylene when used as a scintillation solvent. Data are included from measurements of nonradioactive energy transfer in *p*-xylene and diphenyloxazole organic scintillation solutions. Measurements were made of the energy resolution of a twin-scintillation fast neutron spectrometer. Accurate values of electron drift velocity in purified noble gases and nitrogen were obtained by measuring the transit time of photoelectrons across the gap of a parallel-plate condenser. Information concerning the transport collision cross section of low-energy electrons on noble gases was obtained from drift-velocity data. A method is discussed for the determination of traces of Freon-12 by positive ion emission techniques. Data are reported from late observations of the distribution of radium in the human body; the microscopic distribution of the dose in the skeleton arising from deposited calcium-45, strontium-90, and radium-226 as measured autoradiographically; and determinations of individual alpha emitters in mixtures of alpha emitters. Data are tabulated from measurements of gross fission product radioactivity in air samples and in samples of soils collected from August through November 1959. The soil and air fall-out data are discussed. Measurements were made of the total-body gamma ray spectra of 13 unexposed employees chosen as typical of the civilian population of the Chicago area. Measurements were also made of cesium-137 content and cesium-137/potassium-40 ratios. Data are included from measurements of natural uranium in the lungs of a human. The status is reviewed of a project to study the conditions of persons formerly engaged as radium dial painters and of a project to study the condition of persons who received radium by intravenous administration 21 to 29 years previously. Results are included from a survey of the radioactivity of commercial photomultiplier tubes. The activity induced in meat by high-energy electron bombardment was measured in connection with a study of radiation sterilization and preservation of foodstuffs. Research studies in the field of meteorology reported include descriptions of trial runs of the meteorological model towing tank, a study of errors in wind measurements associated with tower-mounted anemometers, and studies on the effect of con-

vective turbulence in the atmosphere on the diffusion of stack gases. (For preceding period see ANL-6049.) (C.H.)

**16492** BMI-1377

Battelle Memorial Inst., Columbus, Ohio.

PROGRESS RELATING TO CIVILIAN APPLICATIONS DURING AUGUST 1959. Russell W. Dayton and Clyde R. Tipton, Jr. Sept. 1, 1959. Decl. Oct. 8, 1959. 102p. Contract W-7405-eng-92. OTS.

Data are presented on the creep properties of 15% cold-worked Zircaloy-2 at 290, 345, and 400°C. The progress on the development of an isotopic-exchange fuel-element leak-detection system is summarized. A program to develop a thermal-neutron-flux monitoring system for Hanford reactors is reported. Work on the radiometric analysis of calcium in cement was continued. A surveillance program is in progress to determine the effects of fast-neutron irradiation on the mechanical properties of AISI Type 347 stainless steel. A summary of corrosion results obtained on Nb, Nb-Zr, Nb-W, Nb-Mo, Nb-V, Nb-Fe, Nb-Ti, Nb-Ti-Cr, and Nb-Ti-V alloys exposed in high-temperature water and steam is presented. A study of the creep characteristics of Zircaloy-2 at elevated temperatures during exposure to a fast-neutron flux was initiated. A research program was initiated to develop an analytical technique for monitoring the oxygen concentration in large-scale radioactive sodium systems. Data are presented on the corrosion behavior of Nb-U alloys in high-temperature water after 98 days. The development of Th-U-base alloys of improved radiation stability and corrosion resistance is reported. Methods of producing cermets of 90% of theoretical density or better containing 60 to 90 vol.% ceramic fuel are being investigated. The gas-pressure-bonding technique is being investigated as a possible method for fabricating Mo- and Nb-clad ceramic and cermet-type fuels. Data are presented on the densification and green compactibility of UO<sub>2</sub> powders. A summary of tensile-test results for pressure-bonded type 304 stainless steel bond specimens is presented. An investigation of methods for producing dense UC cores is being made. Data are presented on the effect of heat treatment at 1500°C for 1 hr on density and rupture strength of UC. The fission gas release from irradiated fueled-graphite spheres was studied. Thermal-conductivity measurements were completed on two UC specimens prepared by casting. Work on a series of binary Ta-base alloys containing additions of Hf, Th, Ti, W, Y, and Zr is nearing completion. Fuel-element cores consisting of ~20 vol.% UO<sub>2</sub> particles dispersed uniformly in a densely sintered BeO matrix are being developed. Research to develop improved graphite fuel-element cores containing UC or UC<sub>2</sub> particles in an amount equivalent to 20 vol.% of UO<sub>2</sub> is reported. Data are pre-

sented on the fission-gas release from 48.25 wt.% BeO-UO<sub>2</sub> pellets during postirradiation heat treatment in vacuum at 1800 and 2000°F for 24 hr. A study of the radiation stability of ceramic-type fuels under conditions simulating those of MGCR design is in progress. Research concerned with the development of fuel, absorber, and suppressor materials for the SM-2 is reported. In the Gas-Cooled Reactor Program progress of capsule-irradiation is reported for stainless steel-UO<sub>2</sub> and -UN dispersion fuel elements, solid UO<sub>2</sub> and annularly loaded UO<sub>2</sub> fuel pins, and graphite UO<sub>2</sub> fuel bodies. (For preceding period see BMI-1366.) (W.L.H.)

**16493** KAPL-1491

Knolls Atomic Power Lab., Schenectady, N. Y.

REPORT OF THE CHEMISTRY AND CHEMICAL ENGINEERING SECTION FOR NOVEMBER, DECEMBER 1955, JANUARY 1956. Decl. May 18, 1960. 103p. Contract W-31-109-Eng-52. OTS.

Investigations were continued on dissolution and decontamination of irradiated UO<sub>2</sub>-PuO<sub>2</sub> fuel, radiation effects on TBP, separation and nuclear properties of Cf<sup>251</sup>, Cm<sup>245</sup>, Cm<sup>246</sup>, and Cm<sup>247</sup> from irradiated Pu, vapor pressure of PuF<sub>6</sub>, properties of UO<sub>2</sub> slurries in Na, NaK, and H<sub>2</sub>O, corrosion of aluminum alloys, electrorefining of irradiated U, deposition of Zr on graphite, and coating U with Mo. (For preceding period see KAPL-1438.) (M.C.G.)

**16494** UCRL-5932

California. Univ., Livermore. Lawrence Radiation Lab.

THE SOVIET PROGRAM FOR INDUSTRIAL APPLICATIONS OF EXPLOSIONS. Gerald W. Johnson. Mar. 28, 1960. 15p. Contract W-7405-eng-48. OTS.

Extracts from press releases, statements, and articles appearing in technical journals are presented which give insight into the status of the Soviet program for industrial applications of explosions. It is concluded that a vigorous chemical explosive program is being continued. (C.H.)

**16495** UCRL-9093

California. Univ., Berkeley. Lawrence Radiation Lab. CHEMISTRY DIVISION SEMIANNUAL REPORT FOR JUNE THROUGH NOVEMBER 1959. Feb. 8, 1960. 103p. Contract W-7405-eng-48. OTS.

High-energy studies of the (p,2p) reaction in Zn<sup>68</sup> and Fe<sup>57</sup> are being carried out. Measurements of the angular distribution of elastically scattered heavy ions are reported. As a part of a survey of He<sup>3</sup> elastic scattering, the angular distribution of 31-Mev He<sup>3</sup> ions elastically scattered from Cu and Bi in the angular range 20 to 65 deg was measured. The energy spectra and angular distributions of deuterons from the reaction C<sup>12</sup>(α,d)N<sup>14</sup> were studied by using 48-Mev incident helium ions. The study of the (p,α) reaction in Li<sup>7</sup> and Li<sup>6</sup> was started. A study is also being made of the (α,t) reaction in Li<sup>6</sup> and Li<sup>7</sup>. Work was continued on the determination of cross sections for heavy-ion-induced reactions. The mass-spectrometric chain-yield measurements were completed over the mass region (140 ≤ A ≤ 155) for the fission of U<sup>238</sup> induced by 24- and 45.7-Mev helium ions, and the fission of U<sup>235</sup> induced by 45.7-Mev helium ions. Investigation of the fission yield curve for fission produced by the reaction, C<sup>12</sup>(115 Mev) + U<sup>238</sup> → Cf<sup>252</sup> → fission, has given evidence of the existence either of ternary fission or a very asymmetric mode of binary fission. A study of the long-range alpha particles associated with the spontaneous fission decay of Cf<sup>252</sup> was undertaken, using nuclear emulsion techniques. The investigation of the velocity and angular distribution of

prompt neutrons from spontaneous fission of Cf<sup>252</sup> was continued. The self-transfer of Cf<sup>252</sup> is being investigated. Measurements of the half lives of the 74.6-kev excited state of Np<sup>239</sup> and the 68 kev excited state of Ra<sup>226</sup> are presented. An attempt was made to study the influence of the chemical environment on the angular distributions of two gamma cascades in Np<sup>237</sup>. Alpha-particle and gamma-ray studies of the U<sup>229</sup> and U<sup>228</sup> families were made. Several new neutron-deficient isotopes of Sb and Te were produced by nuclear reactions of He<sup>3</sup> and He<sup>4</sup> ions with indium and tin targets of natural and enriched isotopic compositions. Terbium-155 and terbium-156 were aligned in a single crystal of neodymium sulfate at low temperatures, and the angular distribution of the gamma radiation was measured. Work was continued on the determination of the nuclear spins and moments of the radioactive halogen isotopes. The gyromagnetic ratios g<sub>R</sub> of <sub>66</sub>Dy<sup>160</sup> and <sub>74</sub>W<sup>184</sup> were calculated. The paramagnetic-resonance spectrum of tetravalent Pa<sup>231</sup> was observed in a single crystal of Cs<sub>2</sub>ZrCl<sub>6</sub>. A study is being made of the chemical fate of S<sup>35</sup> atoms formed by the slow-neutron irradiations of gaseous sulfur compounds. Americium and plutonium monoxides, AmO and PuO, were prepared by the direct reaction between molten metals and oxygen that was generated from Ag<sub>2</sub>O by thermal decomposition. Two methods for preparing Am metal are being studied. A new permanent-magnet β-spectrograph is described. A relatively high-geometry alpha chamber has been designed, constructed, and tested. The alpha chamber permits the precision measurement of alpha sources deposited on a backing plate. (For preceding period see UCRL-8867.) (W.L.H.)

**16496**

LONG-RANGE POWER MANAGEMENT IN HUNGARY AND THE POWER PLANTS TO BE BUILT IN 1960-1970.

András Léval. *Energia es atomtech.* 13, 15-26(1960) Jan.-Feb. (In Hungarian)

Hungary's power plant construction program is analyzed, with particular attention to fuel resources and imports, specific costs, and methods of estimating future power demands. The plans for 1961-1965, regarded as final, call only for conventional power plants totaling 893.3 Mwe of new installed capacity. The parameters of the planned boiler-turbine sets are discussed. According to the tentative plans for 1966-1970, about 1,500 Mwe of new installed capacity will be built, including a nuclear power plant of about 100 Mwe—the prototype of an unspecified number of nuclear power plants to be built after 1970. It is estimated that by 1970 nuclear power will be economically feasible in Hungary. Estimates are given on the total uranium fuel consumption of Hungary's future nuclear power plants, separately for the gas-cooled graphite moderated and the D<sub>2</sub>O-cooled and moderated types. The view is expressed that plants for the concentration of uranium fuels will never be feasible in Hungary. (JPRS)

**16497**

GEOPHYSICAL EFFECTS ASSOCIATED WITH THE HIGH-ALTITUDE NUCLEAR EXPLOSION. H. Uyeda, T. Obayashi, and S. Ishikawa (Radio Research Labs., [Japan]); H. Maeda (Kyoto Univ.); A. Kimpara (Nagoya Univ., Japan); and Y. Kawabata (Japan Meteorological Agency). *J. Geomagnet. Geoelec.* 11, 39-41(1959). (In English)

A report is given on observations and investigations concerning the geophysical effects associated with the high-altitude nuclear explosions carried out over Johnston Island on August 1 and 12, 1958. The effects under consideration are on the disturbances of the geomagnetism, VLF atmos-

pherics, field strength of the HF waves, the ionosphere, and acoustic and seismic waves. As the result of investigations of the associated phenomena, the mechanism of generation of each phenomenon seems to be very complicated and associated with each other. In view of the time that elapsed after the blast, three distinct periods seem to exist. The typical examples are the two stages of the magnetic disturbance—SSC and the main phase—and the ionospheric disturbance which appeared several hours later and lasted more than ten hours. They will belong to the first, second, and third periods, respectively. (auth)

16498

ATOMIC ENERGY IN THE TRANSPORT INDUSTRY.

Kernenergie 1, 147-8(1958) Feb. (In German)

A brief study is given of some technical-economic questions in the production of nuclear-powered transport vehicles. (T.R.H.)

## BIOLOGY AND MEDICINE

### General and Miscellaneous

16499 TID-5954

Sloan-Kettering Inst. [for Cancer Research], New York. THE USE OF CALCIUM-47 IN DIAGNOSTIC STUDIES OF PATIENTS WITH BONE LESIONS. K. R. Corey, P. Kenny, E. Greenberg, A. Pazianos, O. H. Pearson, and J. S. Laughlin. [1960]. 60p. Contract AT(30-1)-910. OTS.

Presented at the 42nd Annual Meeting of the American Radium Society, March 17, 1960.

Physical aspects of calcium-47 and problems of its production and assay are reviewed. Its energetic gamma spectrum and 4.7 day half-life make it very useful for calcium metabolic studies. Dosimetric considerations in both tracer and therapeutic applications are discussed. Results are reported from kinetic and external counting studies using tracer doses of calcium-47 in patients with a variety of bone lesions. The accretion rate and size of the exchangeable calcium pool were measured in patients with breast carcinoma. The accretion rate was found to be elevated in patients whose bone metastases were clinically active. A whole-body scanner is described which was developed to improve and extend the clinical uses of calcium-47. (C.H.)

16500 JPRS-L-810-N

RESULTS OF THE WORK OF THE SEMINAR AT LENIN-GRAD ON THE RADIobiOLOGY AND PHYSICS OF PENETRATING RADIATIONS. G. A. Gusterin. Translated from Med. Radiol. 4, No. 2, 87-91(1959). 12p. OTS.

A city-wide inter-institute seminar on the biological and physical effects of penetrating radiations was held at Leningrad, U.S.S.R., in 1954. The discussions covered both original scientific investigations and reviews of work reported throughout the world. The recommendations of the international commission on radiological units were reviewed critically, and the scientific basis for evaluating the permissible limits of radiation dosage was discussed. Sources of radioactive contamination, methods for preventing contamination, and decontamination methods were reviewed. Topics discussed include the biological and chemical effects of radiation, the effects of reduced barometric pressure, hypoxia, and reduced blood volume on the course of radiation sickness in mice, applications of luminescent microscopy in radiobiology, the effects of radiation on tumors, radiation effects on immune reactions, the effects of radiation on the course of infections,

and the pathology and treatment of radiation injuries. (C.H.)

16501 JPRS-L-830-N

THE SEVENTH ALL-UNION CONGRESS OF ROENTGENOLOGY AND RADIOLOGY. Yu. M. Sokolov, V. M. Bentsyanova, and L. S. Rozenshtraukh. Translated from Vestnik Rentgenol. i Radiol. 34, No. 1, 82-90(1959). 21p. OTS.

The Seventh All-Union Congress of Roentgenology and Radiology convened in Saratov, U.S.S.R., in October 1958. One hundred and nineteen reports were presented. A general summary is presented of topics discussed. The organization of the roentgeno-radiologic service in the country, problems in terminology, and the training of personnel were discussed. Other topics receiving emphasis include the injurious effects of ionizing radiation and measures of protection against it; hazards from increases in natural background of radiation as a result of nuclear weapons tests; pathological effects of chronic exposure to low levels of radiation; radiation injury resulting from therapeutic uses of radiation; the effectiveness of radioisotopes in therapy of cancer; the effectiveness of super-voltage x radiation and electron beams in therapy; the effectiveness of cobalt-60 teletherapy units in cancer therapy; rotational radiation therapy for the treatment of tumors; problems in x-ray diagnosis of a number of conditions; and the development of equipment for large-frame fluorography. (C.H.)

16502 JPRS-L-1639-D

DIRECT APPLICATION OF AMNIOTISSUE DRESSING IN TREATMENT OF RADIATION ULCER OF THE SKIN.

Ching-hua Kuo. Translation of excerpts from Chung Hua Fang Shē Hsüeh Tsa Chih 6, 444-5(1958). 3p. OTS.

The application of amniotissue dressing directly on the affected area is reported to give good results in the treatment of skin ulcers caused by radiation. (C.H.)

16503 JPRS-2592

MEDICAL RADIOLOGY. Translation of Meditsinskaya Radiologiya Volume IV, No. 4, 1959. 163p. OTS.

16504 JPRS-2592(p.112-20)

THE ACCUMULATION OF CERIUM-144 BY YEAR-OLD CARP AND WATER THYME. G. B. Lebedeva. Translated from Med. Radiol. 4, No. 4, 73-7(1959). 9p.

Experimental results showed that the accumulation of cerium-144 in the tissues of fish is directly dependent on the specific radioactivity of the water. Cerium-144 was accumulated much more rapidly by water thyme than by young carp. (C.H.)

16505 JPRS-2592(p.140-2)

OBSERVATION DEVICE IN A GAMMA THERAPY ROOM. F. M. Lyass. Translated from Med. Radiol. 4, No. 4, 87-8(1959). 3p.

A system of mirrors is described which was devised for the observation of patients in a gamma therapeutic room. (C.H.)

16506

NEUTRON ACTIVATION PAPER CHROMATOGRAPHIC ANALYSIS OF PHOSPHATIDES IN MAMMALIAN CELL FRACTIONS. E. H. Strickland and A. A. Benson (Pennsylvania State Univ., University Park). Arch. Biochem. Biophys. 88, 344-8(1960) June.

Diphosphatidylglycerol (cardiolipin) was found in the mitochondria of a number of cell fractions. Its concentration was estimated by neutron activation chromatographic analysis of the deacylated derivative, 1,3-diglycero-

phosphoryl-glycerol. Microsomes contained little or none of this lipid. The distributions of the other glycerol phosphatides in mitochondria and microsomes were similar. A possible functional role for diphosphatidylglycerol is discussed. (auth)

## 16507

THE UPTAKE OF CALCIUM-45 AND STRONTIUM-85 BY BONE IN VITRO. Joseph Samachson and Hilda Lederer (Montefiore Hospital, New York). Arch. Biochem. Biophys. **88**, 355-60 (1960) June.

Bone shaken at 37°C with buffered solutions containing  $\text{Sr}^{85}$  and  $\text{Ca}^{45}$  took up more  $\text{Ca}^{45}$  than  $\text{Sr}^{85}$ , mostly by exchange. The  $\text{Ca}^{45}/\text{Sr}^{85}$  ratio of 1.2 to 1.4, in the absence of carrier or in the presence of stable Ca, rose to 2.0 or higher as the stable Sr concentration was increased. Human and canine bone powder, pieces of bone, ashed bone, bone treated with ethylenediamine, and apatite all behaved similarly. The addition of inorganic phosphate and changes in pH did not affect the ratio.  $\text{Ca}^{45}/\text{Sr}^{85}$  uptake ratios from beef serum and serum ultrafiltrate were close to 1 in the absence of Sr carrier, apparently because stronger binding of  $\text{Ca}^{45}$  by serum proteins and chelating agents compensated for preferential  $\text{Ca}^{45}$  uptake by bone. Implications of the results are discussed with regard to the use of Sr as an adjuvant in osteoporosis,  $\text{Sr}^{85}$  and stable Sr as tracers for Ca, and the uptake of  $\text{Sr}^{90}$  by bone. (auth)

## 16508

DISSOCIATION CONSTANTS OF STRONTIUM AND YTTRIUM WITH ANIONS OF BIOLOGICAL SIGNIFICANCE. J. Olivard (General Electric Co., Richland, Wash.). Arch. Biochem. Biophys. **88**, 382-3 (1960) June.

Ion exchange methods were used to determine the dissociation constants of phosphate-containing complexes of strontium-90 and yttrium-90 with anions of biological significance. Data are tabulated. (C.H.)

## 16509

BEHAVIOUR OF BONE MARROW CULTURED "IN VITRO" IN PRESENCE OF RADIOACTIVE IRON ( $\text{Fe}^{59}$ ). C. Saccetti, I. Pannacciulli, F. Diena, and A. Tizianello (Università, Genoa). Haematol. Latina (Milan) **2**, 121-30 (1959). (In English)

Guinea pig bone marrow was cultured in vitro with increasing amounts of radioactive iron. Iron-59 uptake was evaluated in erythroblasts and in the cells as a whole. The proliferation, maturation, and production of mature cells of erythroblasts and granuloblasts of normal bone marrow, bone marrow with erythroblastic hyperplasia after venesection and phenylhydrazine, and bone marrow after whole-body x irradiation were determined. (C.H.)

## 16510

RADIOACTIVE ISOTOPES IN BIOLOGY AND MEDICINE. [PART] III. Johannes Meissner (Forschungsinstitut, Borstel, Ger.). Kerntechnik **2**, 163-6 (1960) May. (In German)

The application of radioisotopes in radiotherapy is discussed. The methodic possibilities given are explained in comparison with x-ray therapy. The units for radiation dose and absorbed dose are introduced, and the conclusions for the applicability of various radiation types are described. The application methods offered for therapeutics are outlined and illustrated by an example. The application of sealed preparations which are used in body cavities and tissues and open preparations, especially in the selective irradiation method, is discussed. (tr-auth)

## 16511

A COMPARISON OF IODINE-124 AND IODINE-131 THYROID DOSIMETRY. C. M. E. Matthews and J. F. Fowler (Hammersmith Hospital, London). Nature **186**, 983-4 (1960) June 18.

A comparison is presented of the calculation of thyroid dose of iodine-124 and iodine-131. It is concluded that iodine-124 would be a therapeutic tool of greater precision than iodine-131, both for control of thyrotoxicosis and for thyroid carcinoma. The biological effects of equal doses of the two isotopes are discussed. (C.H.)

## 16512

METABOLISM OF THE  $\text{Th}^{228}$  DECAY SERIES IN ADULT BEAGLE DOGS. I.  $\text{Th}^{228}$  (RdTh). Betsy J. Stover, David R. Atherton, Nancy Keller, and Dawn S. Buster (Univ. of Utah, Salt Lake City). Radiation Research **12**, 657-71 (1960) June.

The metabolism of carrier-free  $\text{Th}^{228}$  (RdTh) in adult beagle dogs was studied for 3.5 years after a single intravenous injection of the radionuclide in a citrate buffer solution. Initially urinary excretion predominates, but the fecal-to-urinary excretion ratio gradually increases so that the two rates are about the same several years after injection. After a few months, decrease in retention from radioactive decay becomes greater than that by excretion. For  $t \geq 100$  days, retention, determined from excretion measurements, is  $R' (\% \text{ injected dose}) = (19.1e^{-0.0011t} + 67.9)e^{-\lambda t}$  where the decay constant  $\lambda = 1.00 \times 10^{-3} \text{ day}^{-1}$ . About 80% of the retained  $\text{Th}^{228}$  is in the skeleton; about 20% is widely distributed in soft tissues, with significant amounts in kidneys and liver. The soft-tissue  $\text{Th}^{228}$  decreases more rapidly than that in the skeleton. Comparison of these findings with those from studies with chemically similar tetravalent  $\text{Pu}^{239}$  shows general similarities in beagle metabolism of  $\text{Th}^{228}$  and  $\text{Pu}^{239}$  but also some significant differences. (auth)

## 16513

STRONTIUM STUDIES IN BEAGLES. B. W. Glad, C. W. Mays, and W. Fisher (Univ. of Utah, Salt Lake City). Radiation Research **12**, 672-81 (1960) June.

Previous skeletal irradiation from bone-deposited radionuclides does not seem to influence the metabolism of a  $\text{Sr}^{85}$  tracer in beagles under the conditions, dose rates, and times studied. Confinement immediately after the injection of a  $\text{Sr}^{85}$  tracer reduces its retention. As the age of the beagles increases from 6 months to 10 years, their retention of a  $\text{Sr}^{85}$  tracer decreases. The fact that strontium retention in beagles is less than radium retention was verified in a  $\text{Sr}^{85}$ - $\text{Ra}^{226}$  double-tracer study. (auth)

## 16514

Naamloze Vennootschap tot Keuring van Electrotechnische Materialen, Arnhem, Netherlands.

POOLING RESULTS OF WOUNDS CONTAMINATED BY INSOLUBLE URANIUM COMPOUNDS. H. Wijker. p.115-18 of "Health Physics in Nuclear Installations Symposium, Risø, May 25-28, 1959." (In English)

The treatment of wounds contaminated by insoluble uranium compounds is discussed. The determination of the ratio of contaminant remaining in the wound may depend on the location, type and size, and method of treatment. Only one case has been encountered for which this ratio has been determined. The form submitted for this case is included. (B.O.G.)

## 16515

ON THE STRUCTURE OF MAMMALIAN CHROMOSOMES DURING SPERMATOGENESIS AND AFTER RADIATION

WITH SPECIAL REFERENCE TO CORES. B. R. Nebel (Argonne National Lab., Lemont, Ill.). p.227-30 of "Vierter Internationaler Kongress für Elektronenmikroskopie, Berlin, 10-17 September, 1958." Band II, Biologisch-Medizinischer Teil. W. Bargmann, G. Möllendorf, H. Niehrs, D. Peters, E. Ruska, and C. Wolpers, eds. Berlin, Springer-Verlag, 1960.

Impressions gained from light and electron microscopy were synthesized into a working hypothesis of chromosome structure in interphase and early somatic and meiotic prophase. The hypothesis is said to fit theory and facts as far as they are known. (C.H.)

## Biochemistry, Nutrition, and Toxicology

16516 HW-53362

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

ACCUMULATION OF RADIOISOTOPES IN RATS CHRONICALLY EXPOSED TO REACTOR EFFLUENT WATER. R. F. Palmer. May 13, 1958. Decl. Apr. 28, 1960. 18p. Contract W-31-109-Eng-52. OTS.

Eight radioisotopes were identified and their concentrations measured in rats that were maintained for one year with concentrated reactor effluent water as their sole source of drinking water. The concentrations of  $Zn^{65}$  in both skeleton and soft tissue were higher than those of any other radioisotope measured. An unidentified constituent (or constituents) of the rare earth fraction, and  $P^{32}$ , ranked second and third in concentration. Despite the fact that the water drank by the animals contained levels of radioisotope contamination several thousand times higher than those which exist in the Columbia River below the Hanford reactors, all radioisotope concentrations measured were only small fractions of the maximum permissible body concentrations recommended for humans by the International Commission on Radiological Protection. (auth)

16517 JPRS-2592(p.129-37)

THE TOXICOLOGY OF URANIUM COMPOUNDS. D. I. Zakutinskii (Zakutinsky) and O. S. Andreeva (Andreyeva). Translated from Med. Radiol. 4, No. 4, 81-5(1959). 9p.

Uranium intoxication is characterized by damage to the entire organism. Results are reviewed from a number of studies which support this conclusion. (C.H.)

16518

THE BIOSYNTHESIS OF NICOTINE FROM ISOTOPICALLY LABELED NICOTINIC ACIDS. R. F. Dawson, D. R. Christman, A. D'Adamo, M. L. Solt, and A. P. Wolf (Brookhaven National Lab., Upton, N. Y. and Columbia Univ., New York). J. Am. Chem. Soc. 82, 2628-33(1960) May 20.

The four specific ring hydrogen-labeled nicotinic acids were prepared and fed to tobacco root cultures in sterile media, then the nicotine produced by the roots was isolated and analyzed. Recoil tritium and carbon-14 labeled nicotinic acid were similarly employed. The nicotine from all of these except nicotinic acid-6-t show similar and substantial incorporation into the nicotine. Oxidation of nicotinic acid obtained from the nicotine, to the corresponding 2- and 6-pyridones indicate that the position of hydrogen label is conserved during the conversion to nicotine. The 6-labeled acid gave less than 10% of the amount of incorporation shown by the other acids, indicating the probability of enzymatic attack on the 6-position of nicotinic acid dur-

ing its conversion to nicotine by the tobacco roots. The conversion probably does not proceed via oxidation at the 6-position, since both 6-hydroxynicotinic acid- $N^{15}$  and 1-methyl-6-oxynicotinamide-2-t failed to be incorporated. The possibility that the acid is incorporated into nicotine via a 1,6-dihydro intermediate is being investigated. Nicotinamide is incorporated to at least as great an extent as is the corresponding labeled acid. (auth)

16519

THE BIOSYNTHESIS OF OPIUM ALKALOIDS. I. THE INTERRELATIONSHIP AMONG MORPHINE, CODEINE AND THEBAINE. Henry Rapoport, Frank R. Stermitz, and Don R. Baker (Univ. of California, Berkeley). J. Am. Chem. Soc. 82, 2765-72(1960) June 5.

Plants of *Papaver somniferum* L. were grown in the presence of  $C^{14}O_2$  for two-hour, six-hour, and eight-day periods, after which morphine, codeine, and thebaine were isolated. The incorporation of radioactivity into each of these alkaloids was determined for the intact compounds, the various O- and N-methyl groups, and the ring skeleton. Differences found in the ring skeleton labeling are best accommodated by a scheme in which thebaine is the precursor of the other morphine alkaloids. Morphine appears to be a storage product formed from codeine by demethylation. In addition, these short periods of biosynthesis allowed the development of a simplified biosynthesis chamber adaptable for research purposes and yet capable of producing appreciable quantities of alkaloids of high specific activity. (auth)

16520

EXCRETION OF RADIOIODINE IN HUMAN MILK.

John C. Weaver, Michael L. Kamm, and R. Lowry Dobson (Alta Bates Hospital, Berkeley, Calif.). J. Am. Med. Assoc. 173, 872-5(1960) June.

The possibility that  $I^{131}$  administered to a lactating woman might appear in the milk and might reach the nursing in harmful amounts was studied in six nursing mothers. Most of them were already in the process of weaning their babies. The  $I^{131}$  was given by mouth to the mother in doses of either 10 or 30  $\mu$ c just after the final breast feeding. The quantity of  $I^{131}$  that appeared in the milk secreted in 48 hours after administration was 1.4, 3.9, 0.14, 0.03, 6.2, and 26.8% of the total that had been administered, respectively, to the six mothers. Most of the  $I^{131}$  was secreted during the first 24 hours. It is recommended that candidates for diagnostic tests with  $I^{131}$  be questioned about lactation and that nursing should be interrupted for 24 hours, or, in the case of a large diagnostic or therapeutic dose, until measurements indicate that the  $I^{131}$  content of the milk is no longer significant. (auth)

16521

United Kingdom Atomic Energy Authority. Industrial Group. Windscale Works, Sellafield, Cumb., England. CRITICAL SURVEY OF METHODS FOR THE DETERMINATION OF RADIONUCLIDES IN URINE. F. J. Woodman. p.105-14 of "Health Physics in Nuclear Installations Symposium, Risø, May 25-28, 1959." (In English)

These main problems in the analysis of urine for radionuclides are discussed: difficulties resulting from the extremely low levels of radioactivity, the effect of their probable existence in complex rather than simple ionic form, and securing representative samples. A survey is given of the methods used in the detection and measurement of natural and enriched uranium, plutonium, tritium, and strontium-90. (B.O.G.)

## Fallout and Ecology

16522

EXCRETION AND RETENTION OF RADIOACTIVE STRONTIUM IN NORMAL MEN FOLLOWING A SINGLE INTRAVENOUS INJECTION. Margaret Bishop, G. E. Harrison, W. H. A. Raymond, and Alice Sutton (M. R. C. Radiobiological Research Unit, Harwell, Berks, Eng.) and J. Rundo (Atomic Energy Research Establishment, Harwell, Berks, Eng.). *Intern J. Radiation Biol.* 2, 125-42 (1960) Apr. (In English)

The fecal and urinary excretion rates of strontium-85 following a single injection, in two normal adults, were measured up to 140 days after the dose, while the retention, as observed by means of a whole-body counter, has been determined up to 1 year. It is shown that the retentions can be fitted to a power law or to a four-term exponential expression. The turnover of the dose is regarded as a three-stage process, involving rapid excretion up to 20 to 30 days accounting for about 70% of the dose; an intermediate-rate process comprising about 15% of the dose, and a chronic retention stage when the excretion is very small. The urinary-excretion ratio was related to the body burdens by a single expression, and the dose to the bone is evaluated on the basis of a uniform distribution of radioactive strontium. (auth)

16523

RADIOACTIVE FALLOUT DURING 1959. W. Anderson, R. E. Bentley, L. K. Burton, J. O. Crookall, and C. A. Greatorex (Royal Cancer Hospital, London). *Nature* 186, 925-8 (1960) June 18.

The concentration of strontium-90 in rain falling over Great Britain rose sharply during the first half of 1959 despite the suspension of nuclear weapons testing from November 1958 until February 1960. Results are presented from measurements of the radiostrontium content of rain water, sampled through 1959, and the concentration of various short-lived fission products present in surface air during the same period. The results are discussed in relation to current theories on the transport of fission products in the atmosphere. (C.H.)

## Radiation Effects on Living Tissues

16524 A/AC.82/G/L.326

Akademiya Meditsinskikh Nauk S.S.S.R.

NEKOTORYE DANNYE O VLIYANII IONIZIRUYUSHCHIKH IZLUCHENII NA NUKLEINOVYE VESHCHESTVA V ZHROOM ORGANIZME. (Data on Ionizing Radiation Effects on Nucleic Substances in Living Organism). N. N. Demin. 1959. 35p.

A review is presented of data on the high radiolability of nucleic substances, particularly of the high polymer DNA, in hematopoietic organs. The comparable stability of DNA and DNP remains a problem. New data are presented on nucleotide and nucleoside content variations in irradiated tissues. Data on increased excretion of desoxycytidine in urine during radiation injuries were confirmed. 62 references. (R.V.J.)

16525 AD-230308

Kentucky. Univ., Lexington.

THE EXTENSION OF STORAGE LIFE OF FRUIT AND VEGETABLES BY IONIZING RADIATION. Report No. 4 (Progress) [for] January 27-April 26, 1959. D. C. Martin. 4p. Project No. 7-84-01-002. Contract QMR E (NATIC) No. 87 (AGREEMENT).

Gamma irradiated sweet corn, broccoli, and cauliflower were rated by a taste panel at various periods after irradiation. The evaluations were the same as those made immediately after irradiation. (auth)

16526 AD-230343

Stanford Research Inst., Menlo Park, Calif.

RADIOACTIVITIES PRODUCED IN FOODS BY HIGH ENERGY ELECTRONS. Report No. 7 (Progress) [for] January 15, 1959 to April 14, 1959. Richard A. Glass. May 14, 1959. 15p. Project No. 7-84-01-002. Contract DA-19-129-QM-1100.

Additional information was obtained on characteristics of radioactivity production in foods from a series of irradiations of simulated food media (aqueous solutions of food elements). Samples of plastic, aluminum, and tin-plate food container materials were irradiated to determine radioactivity production, and theoretical calculations of radioactivity production were continued to provide a second method for determining radioactivities produced in food. (For preceding period see AD-220364.) (J.R.D.)

16527 TID-5976

Yale Univ., New Haven.

INVESTIGATIONS ON THE CYTOGENETIC EFFECTS OF RADIATION. Progress Report [for] June 1, 1959-May 31, 1960. 48p. Contract AT(30-1)-872. OTS.

It was determined that nitrous acid, ethyl methane sulfonate, and 5-bromodeoxyuridine mutagens could produce forward mutations in *Neurospora* at the various loci controlling adenine, histidine, and pantothenic acid biosynthesis. Data are presented on the number of complementing ad-4 mutants obtained with adenylosuccinase-less mutants. The preparation of adenylosuccinase from four different heterocaryons growing without exogenous adenine is reported. The heterocaryons were formed by cytoplasmic fusion in pairwise combinations of six different ad-4 mutants of various mutagenic origins and located in various parts of the complementation map of the locus. Certain properties of these enzyme preparations were compared with those of the wild type enzyme. It was determined that all five ad-4 mutants induced by  $\text{HNO}_2$  in the desoxyribonucleic acid are capable of reverse mutation and therefore restoration of adenylosuccinase activity. The level of enzyme activity in such reverions is discussed. 206 primary ad-8 mutants of x-ray, UV, chemical, or spontaneous origin were isolated by the filtration concentration method and 64 secondary ad-8 mutants were obtained from revertant strains at this locus. Heterocaryon complementation patterns and a preliminary linkage map of the ad-8 locus are presented. Two methods of detecting ribonuclease activity in *Neurospora* are described. (C.J.G.)

16528 TID-6043

Marquette Univ., Milwaukee.

PROGRESS REPORT FOR THE PERIOD OCTOBER 1, 1959 TO SEPTEMBER 30, 1960. 12p. Contract AT(11-1)-820. OTS.

Preliminary results are reported from studies on the antibody responses in irradiated rabbits and the effects of irradiation on histologic reaction in the rabbit spleen during antibody formation. (C.H.)

16529 USNRDL-TR-421

Naval Radiological Defense Lab., San Francisco.

OPERATIONAL SIGNIFICANCE OF BIOLOGICAL RECOVERY FROM CHRONIC IRRADIATION: A COMPARISON OF SEVERAL RECOVERY THEORIES. E. Shapiro.

May 16, 1960. 49p.

Potential hazards to military personnel due to residual

radiation from fall-out are considered. Several theories that predict the way in which the body recovers from chronic exposure to whole-body radiation are applied to a typical operational situation. Adaptations of the Schwarzschild Law and Smith's modification of the Blair theory are considered. The general postattack situation is broken down into preshelter, shelter, and postshelter periods, and the recovery from doses received during each of these periods is computed according to each of the theories. The dependency of certain operational parameters on choice of theory is investigated. Among the parameters studied are shelter entry time, shelter residual number (shielding factor), shelter exit time, and postshelter radiological recovery effort. The study indicates that except in special cases the operational parameters are relatively insensitive to the choice of theory. (C.H.)

## 16530 AEC-tr-3998

RADIATION GENETICS. M. A. Arsen'eva, M. L. Belgovskii (Belgovsky), N. L. Delone, O. N. Petrova, V. V. Khvostova, and N. I. Shapiro. Translated for Oak Ridge National Lab. from Itogi Nauki: Biol. Nauki, Akad. Nauk S.S.R., No. 1, 329-79(1957). 83p. JCL or LC.

Results are presented from a thorough quantitative evaluation of genetic changes caused by radiation. Recent data are reviewed on the physical elements of heredity; studies on genetic effects as functions of dosage and time, the relation between genetic effects and the form of radiation, the effects of environmental conditions on sensitivity to radiation, uses of radiation in agriculture, and genetic effects of radiation on mammals. It is concluded that the genetic effects of radiation on man do not lead to sharply expressed changes in the population because of the great differences in the genotypes of men and because of the differences in their environment. Data are reviewed from studies on the offspring of parents subjected to various amounts of radiation resulting from the atomic explosions over Nagasaki and Hiroshima. 174 references. (C.H.)

## 16531 JPRS-L-902-N

DEMYELINIZATION OF THE CENTRAL NERVE FIBERS PRODUCED BY THE TOTAL ACTION OF IONIZING RADIATION ON ANIMAL-ORGANISMS. A. F. Bibikova. Translated from Arkh. Patol. 21, No. 5, 19-24(1959). 9p. OTS.

The myelin sheaths of the central nerve fibers are very sensitive to the effect of ionizing radiation. A total-body effect on the bodies of animals with ionizing radiation produces an acute or chronic development of a demyelinizing process in the central nervous system. The development of the demyelinizing process in remote periods after the x irradiation shows convincingly the error of the ideas of certain authors concerning the special resistance of the nervous system to the effect of ionizing radiation. (auth)

## 16532 JPRS-2592(p.12-20)

CHANGES IN VASCULAR PERMEABILITY AND IN CAPILLARY STABILITY IN CONNECTION WITH HEMORRHAGIC PHENOMENA IN RABBITS AFTER IONIZING IRRADIATION. N. I. Arlashchenko. Translated from Med. Radiol. 4, No. 4, 10-16(1959). 9p.

This paper was previously abstracted from the original language and appears in NSA, Vol. 13, as abstract No. 15866.

## 16533 JPRS-2592(p.21-7)

A STUDY OF THE NERVOUS MECHANISMS OF DISTURBANCES IN HIGHER NERVOUS ACTIVITY OF WHITE RATS FOLLOWING SINGLE EXPOSURE TO IONIZING RADIATION IN THE EARLY STAGES OF ONTOGENESIS. A. P. Chesnokova. Translated from Med. Radiol. 4, No. 4, 16-21(1959). 7p.

This paper was previously abstracted from the original language and appears in NSA, Vol. 13, as abstract No. 15867.

## 16534 JPRS-2592(p.28-36)

THE INFLUENCE OF X-IRRADIATION ON CERTAIN PARTS OF THE PERIPHERAL NERVOUS SYSTEM IN RATS. Jan (Yan) Gromada and Pschemisl (Pschemysl) Polachek. Translated from Med. Radiol. 4, No. 4, 21-7(1959). 9p.

This paper was previously abstracted from the original language and appears in NSA, Vol. 13, as abstract No. 15868.

## 16535 JPRS-2592(p.37-42)

THE OXYGEN REQUIREMENTS OF RATS WITH MODIFIED RADIORESISTANCE DURING IRRADIATION OF THEM WITH X-RAYS. I. S. Belokonskii (Belokonski). Translated from Med. Radiol. 4, No. 4, 27-31(1959). 6p.

This paper was previously abstracted from the original language and appears in NSA, Vol. 13, as abstract No. 15869.

## 16536 JPRS-2592(p.43-50)

THERAPEUTIC USE OF STREPTOMYCIN AND PENICILLIN IN INFLAMMATORY PROCESSES IN IRRADIATED ANIMALS. V. F. Sosova. Translated from Med. Radiol. 4, No. 4, 31-6(1959). 8p.

This paper was previously abstracted from the original language and appears in NSA, Vol. 13, as abstract No. 15870.

## 16537 JPRS-2592(p.51-63)

THE INFLUENCE OF CHRONIC CONTINUOUS IONIZING IRRADIATION ON IMMUNITY. P. N. Kiselev and P. A. Buzini. Translated from Med. Radiol. 4, No. 4, 36-44(1959). 13p.

This paper was previously abstracted from the original language and appears in NSA, Vol. 13, as abstract No. 15871.

## 16538 JPRS-2592(p.64-73)

THE INFLUENCE OF IONIZING RADIATION ON THE COURSE OF DYSENTERY. E. K. Dzhikidze and A. S. Aksanova. Translated from Med. Radiol. 4, No. 4, 44-50(1959). 10p.

This paper was previously abstracted from the original language and appears in NSA, Vol. 13, as abstract No. 15872.

## 16539 JPRS-2592(p.74-84)

THE CONDITION OF THE TESTES OF RATS UPON LOCAL IRRADIATION OF THEM AND IN RADIATION SICKNESS. B. A. Fedorov. Translated from Med. Radiol. 4, No. 4, 50-7(1959). 11p.

This paper was previously abstracted from the original language and appears in NSA, Vol. 13, as abstract No. 15873.

## 16540 JPRS-2592(p.85-92)

THE PROBLEM OF THE BIOLOGICAL EFFECTS OF BARIUM-140. Yu. I. Moskalev and V. (U.) N. Strel'tsova. Translated from Med. Radiol. 4, No. 4, 57-60(1959). 8p.

This paper was previously abstracted from the original language and appears in NSA, Vol. 13, as abstract No. 15874.

## 16541 JPRS-2592(p.93-9)

INTRA-TISSUE INJECTION OF RADIOACTIVE COLLOIDAL GOLD. M. I. Svetlakov and V. A. Odinokova. Translated from Med. Radiol. 4, No. 4, 61-4(1959). 7p.

This paper was previously abstracted from the original language and appears in NSA, Vol. 13, as abstract No. 15875.

**16542** JPRS-2592(p.139)

THE INFLUENCE OF IONIZING RADIATION ON THE COURSE OF LATENT SALMONELLA INFECTION. B. A. Chukhlovin. Translated from Med. Radiol. 4, No. 4, 86(1959). 1p.

Radiation sickness was found to activate latent *Salmonella* infections in mice and the infection in turn aggravated the course of radiation sickness. (C.H.)

**16543** NP-tr-439

DIGESTION WITH PEPSIN OF SERUM ALBUMIN IRRADIATED WITH GAMMA RAYS OUTSIDE AND WITHIN THE BODY. Ya. A. Epshtein and E. A. Zabozlaeva. Translated by V. Beak (U.K.A.E.A. Atomic Energy Research Establishment) from Med. Radiol. 1, No. 6, 65-9(1956). 9p. JCL or LC.

Results of investigations of the rate and degree of pepsinolysis in gamma irradiated serum albumin are discussed. The changes in serum albumin resulting from internal irradiation with  $\gamma$  rays closely resemble those observed *in vitro*. The effects are evident during pepsin breakdown tests, and are attributed to weakening or disruption in the protein molecule bonds. (J.R.D.)

**16544** NP-tr-443

RADIATION-INDUCED MUTATIONS AND PLANT BREEDING. F. Scholz. Translated by A. Schoenfeld (U.K.A.E.A. Atomic Energy Research Establishment) from Atompraxis 5, 475-81(1959). 24p. JCL.

This paper was previously abstracted from the original language and appears in NSA, Vol. 14, as abstract No. 7228.

**16545** UCRL-Trans-521

RELATIONSHIP BETWEEN POST-RADIATION REVIVIFICATION REACTIONS AND THE DENSITY OF THE CELLULAR SUSPENSION, TEMPERATURE AND OXYGEN TENSION. V. I. Korogodin, B. N. Tarusov, and A. Kh. Tambiev. Translated by Richard B. Mudge from Biofizika 4, 224-7(1959). 12p. (Includes original, 4p.). JCL or LC.

This paper was previously abstracted and appears in NSA, Vol. 14, as abstract No. 9340.

**16546**

RADIOBIOLOGICAL ANALYSIS OF THE DEPENDENCE OF *ESCHERICHIA COLI* INACTIVATION ON THE DOSE OF X-IRRADIATION. N. I. Shapiro, I. F. Nenarokova, and V. I. Suslikov (Inst. of Biological Physics, Academy of Sciences, Moscow). Biophysics (U.S.S.R.) (English Translation) 4, No. 5, 53-61(1959).

A method was tested aimed at detecting the presence of two mechanisms of radiation death of the cells of *E. coli*. The genetic mechanism is connected with the process of cell division and the physiological is not connected with the process of cell division. The radiation death of *E. coli* was essentially the result of disturbances of the genetic mechanism whereas damage of a physiological character was of secondary importance. The dependence of the disturbances produced by the genetic and physiological mechanisms on the dose of x radiation is exponential in character. A difference was seen between the values for the volume occupied by the genetically active structures in the *E. coli* cell established by radiation micrometry and the value of the volume of DNA established by biochemical methods. The possible reasons for this discrepancy are discussed. (auth)

**16547**

EFFECT OF RADIATIONS ON EHRLICH ASCITES CARCINOMA IN CONNEXION WITH THE PROBLEMS OF PROTECTION. I. CELLULAR CHARACTER OF THE

ACTION OF PROTECTIVE SUBSTANCE. Ye. N.

Tolkacheva (Inst. of Biological Physics, Academy of Sciences, Moscow). Biophysics (U.S.S.R.) (English Translation) 4, No. 5, 61-8(1959).

Results are reported from a study of the protective action of chemical substances on survival rate of mice exposed to various doses of radiation and the development of ascites carcinoma as a function of radiation dose. It was concluded that the protective action of the various chemical substances tested, including the narcotics, is achieved through direct protection of the irradiated cells. The high efficacy of the protective action of  $\beta$ -aminoethylisothiuronium bromide hydrobromide during whole-body irradiation and the fact that there is no protective effect on cancer cells (Ehrlich ascites carcinoma) may be of great interest with a view to use of this preparation in the x-ray therapy of patients with cancer. (C.H.)

**16548**

ACTION OF X-RAYS ON THE PLACENTAL BARRIER AT DIFFERENT STAGES OF PREGNANCY. MECHANISMS OF ACTION OF X-RADIATION ON THE TRANSFER OF  $P^{32}$  THROUGH THE PLACENTAL BARRIER FROM MOTHER FOETUS. L. D. Luk'ianova (Inst. of Biological Physics, Academy of Sciences, Moscow). Biophysics (U.S.S.R.) (English Translation) 4, No. 5, 69-77(1959).

A single whole-body irradiation of pregnant animals with a lethal dose of x rays (rabbits with 850 to 1000 r and guinea pigs 600 r) depressed the uptake of  $P^{32}$  by both placental tissues and fetus. X irradiation sharply depressed incorporation of  $P^{32}$  into the high molecular phosphorus compounds of the placental and fetal tissues, and increased the permeability of the placental barrier. The fall in the total radioactivity of the placental and fetal tissues after irradiation together with increased permeability of the placenta to  $P^{32}$  was seen within 2 hr of the action of penetrating radiations and is to be explained by the sharp decline in the synthesis of high molecular phosphorus compounds. The modified permeability of the placental barrier due to irradiation was apparently unrelated to changes in the activity of the enzyme hyaluronidase in the placenta. The most profound disturbances in the exchange of  $P^{32}$  between mother and fetus following irradiation were manifest in the first half of pregnancy. (auth)

**16549**

DIRECT ACTION OF X RAYS ON THE GROWTH *IN VITRO* OF NERVE FIBERS OF THE IRRADIATED SPINAL COLUMN OF CHICKEN EMBRYOS. Raoul Michel May and Jean-Pierre Denèfle (Faculté des Sciences, Paris). Compt. rend. 250, 3229-31(1960) May 9. (In French)

In order to detect the appearance of radiolesions and to follow their evolution, the direct effects of x rays on the growth of nerve fibers issuing from the spinal cord of 7-day-old chicken embryos were analyzed qualitatively and quantitatively. Irradiation doses of 3400, 3825, and 4500 r were used on the *in vitro* samples. The irradiation causes a degeneration of the nerve fibers more rapidly than that in the non-irradiated controls only with doses of 3400 r or more. Minimum and average growth predominate in the case of irradiated fragments, whereas the control fiber exhibits more optimum growth. (tr-auth)

**16550**

EXCESS OF OVULATION FOLLOWING THE EXPOSURE OF RATS TO X-RAY TREATMENT. E. A. Pozhidaev (Inst. of Experimental Medicine, Academy of Medical Sciences, USSR). Doklady Akad. Nauk S.S.R. 131, 670-2(1960) Mar. 21. (In Russian)

Radiation effects on fetus development in irradiated ovum cells were studied in white rats exposed to 600 r at 40 cm distance. The data obtained with whole-body exposure, exposure of both ovaries with the rest of the body screened, whole-body exposure with screening of both ovaries, exposure of one ovary with the rest of the body screened, and whole-body exposure with screening of one ovary confirmed the data of L. B. Russel et al. (Rec. Genet. Soc. Am. 22, 97, 1953) on the increase of the amount of yellow bodies in the ovaries of irradiated non-pregnant rats. Additional information is given on excess ovulation in irradiated rats. (R.V.J.)

## 16551

TUMORS IN MICE AFTER PULMONARY DEPOSITION OF RADIOACTIVE PARTICLES. L. A. Temple, S. Marks, and W. J. Bair (General Electric Co., Richland, Wash.). Intern. J. Radiation Biol. 2, 143-56(1960) Apr. (In English)

The intratracheal administration to BAF<sub>1</sub> or CAF<sub>1</sub> mice of plutonium and ruthenium particles suspended in Tween-80 or Pluronics caused an increased incidence of pulmonary adenomas compared with controls at levels of 0.1  $\mu$ c Pu<sup>239</sup>O<sub>2</sub> and 3.0  $\mu$ c Ru<sup>106</sup>O<sub>2</sub>. Decreased incidence of adenomas was obtained at 0.16  $\mu$ c Pu<sup>239</sup>O<sub>2</sub> and 24.0  $\mu$ c Ru<sup>106</sup>O<sub>2</sub>. Intravenous administration of similar particles caused an increased incidence at a level of 0.16  $\mu$ c Pu<sup>239</sup>(OH)<sub>4</sub> and a decrease at 0.37  $\mu$ c Pu<sup>239</sup>O<sub>2</sub>. Certain inconsistencies in the incidence values were noted. Histological lesions resulting from deposition of plutonium particles included fibrosis with bronchiolar proliferation and squamous metaplasia. Ruthenium particles caused the presence of numerous bizarre cells in fibrotic lesions. Plutonium particles were considered responsible for the development of two squamous-cell carcinomas and a bronchiolar carcinoma. Two bronchiolar carcinomas occurred in ruthenium-treated animals. (auth)

## 16552

NUMBER OF SPERMATOGONIA AFTER X-IRRADIATION OF THE ADULT RAT. E. A. Jones (Univ. of Birmingham, Eng.). Intern. J. Radiation Biol. 2, 157-70(1960) Apr. (In English)

The testes of adult rats were exposed to 0 to 3000 r x irradiation, and the animals were killed 6 hours to 21 days after treatment. The numbers of type-A, intermediate, and type-B spermatogonia, degenerating cells and mitotic figures were counted in fifty cross sections of seminiferous tubules in each testis. Statistical analyses showed that a curvilinear relationship exists between the number of type-A spermatogonia, and the number of intermediate and type-B spermatogonia, and the dose administered and the time after irradiation. The survival curves for type-A spermatogonia are indicative of a population of cells possessing a heterogeneity of radio-sensitivities. A comparison of the present results with corresponding data reported for the mouse by Oakberg reveals that for a given dose, the rate of depletion and subsequent recovery of spermatogonia is slower, and the incidence of degenerating cells lower, in the rat than in the mouse. The results suggest that the depletion of spermatogonia in the rat may be due primarily to an inhibition of mitosis of some type-A spermatogonia rather than to cell-death. (auth)

## 16553

STUDY OF THE IMPORTANCE OF TIME FACTORS IN WHOLE-BODY IRRADIATION. H. J. Maurer and W. Minder (Röntgeninstitut der Universität, Bern and Radiuminstitut, Bern). Intern. J. Radiation Biol. 2, 171-6 (1960) Apr. (In German)

Doses of 700 and 800 r x radiation induced a significant difference in response in mice when administered at dose rates varying from 5 to 500 r/min. It was concluded that the total dose alone was responsible for the effects observed in dose rates above 50 r/min. Problems of dosimetry are discussed. (C.H.)

## 16554

CELL MIGRATION AND ABNORMAL CRYPT-CELL ENLARGEMENT IN THE SMALL INTESTINE OF X-IRRADIATED MICE. R. A. McGrath (Oak Ridge National Lab., Tenn.). Intern. J. Radiation Biol. 2, 177-85(1960) Apr. (In English)

The dose-response relation of abnormal intestinal crypt-cell enlargement was observed after x-ray doses from 500 to 10,000 r. Enlargement of the largest intestinal crypt cells is a function of x-ray dose, being greater with increasing dose. Greatest enlargement was observed 48 to 60 hours after all doses studied. Analysis of a number of cell populations showed that cell loss from the crypt region by death and by migration on to the villus is accompanied by abnormal crypt-cell enlargement and possibly migration of the villus-core stroma into the crypt region. Greatest enlargement 48 to 60 hours after all doses is interpreted as a result of cell migration into an environment that does not support growth. Experiments using tritiated thymidine indicate that crypt-cell enlargement is not associated with polysomy of the largest abnormally-enlarged cells. Abnormal crypt-cell enlargement was considered as a possible result of water uptake, polysomy, or unbalanced growth. (auth)

## 16555

SERUM-ALBUMIN METABOLISM IN X-IRRADIATED MICE WITH IMPLANTED RAT BONE-MARROW. Wallace Friedberg (Oak Ridge National Lab., Tenn.). Intern. J. Radiation Biol. 2, 186-95(1960) Apr. (In English)

The kinetics of loss of <sup>1</sup><sup>31</sup>-labeled human-serum albumin, the rate of incorporation of glycine 1-C<sup>14</sup> into endogenous-serum albumin, and the serum-albumin concentration and pool size were studied in x-irradiated mice treated with rat bone-marrow. Comparisons were made with unirradiated mice and with x-irradiated mice protected by lead shielding over one femur or by the radiation protective compound, S, 2-aminoethylisothiuronium bromide hydrobromide. The results indicated that, in the mice with implanted rat bone-marrow, there was an increased fractional rate of loss of endogenous-serum albumin (greater than any increase in synthesis) that led to a decrease in the serum-albumin pool. Observations of glycine 1-C<sup>14</sup> incorporation suggested increased albumin synthesis. The serum-albumin concentration was subnormal; presumably because of the decreased pool and a possible increase in the plasma volume. The increased fractional rate of loss of serum albumin was attributed to increased catabolism or leakage of protein into the gastrointestinal tract or both. It could not be ascribed to renal excretion, since no protein-bound radioactivity was detected in the urine. (auth)

## 16556

X-RAY SENSITIVITY OF PRIMARY SPERMATOCYTES OF THE MOUSE. E. F. Oakberg and R. L. DiMinno (Oak Ridge National Lab., Tenn.). Intern. J. Radiation Biol. 2, 196-209(1960) Apr. (In English)

The radiation sensitivity of mouse primary spermatocytes to cell-killing was estimated by the number of spermatids produced; sensitivity to chromosome breakage was measured by scoring abnormal divisions at anaphase I

and II. There was an inverse relation between cell-killing and chromosome breakage: pre-leptotene was the most sensitive and diakinesis-metaphase I the most resistant to induction of cell death; whereas pre-leptotene and leptotene were the most resistant and metaphase I the most sensitive to chromosome breakage. The relative sensitivities of primary spermatocyte stages to chromosome breakage are similar to those observed for meiotic cells in other organisms. Stage differences between leptotene and pachytene in sensitivity to chromosome breakage in the mouse are as large as those sometimes claimed for species differences. The need for accurate information on the duration of spermatogenesis is emphasized in order that species comparisons should not be confused with stage differences in sensitivity. Determination of the number and morphology of spermatozoa ejaculated at successive intervals after irradiation revealed no changes as spermatozoa and spermatids were utilized, a decrease in number and an increase in abnormal sperm from spermatocytes, a severe oligospermia from destruction of spermatogonia, and a return to normal number after regeneration of the testis. (auth)

## 16557

SYNTHESIS OF N'-METHYLNICOTINAMIDE IN X-IRRADIATED RATS. M. K. Nerurkar and M. B. Sahasrabudhe (Atomic Energy Establishment, Trombay, India and Indian Cancer Research Centre, Bombay). Intern. J. Radiation Biol. **2**, 210-17 (1960) Apr. (In English)

The influence of 600 r total-body x-irradiation on the formation and excretion of N'-methylnicotinamide (N'-MeNA) was investigated. A significant increase in the urinary excretion of N'-MeNA (67.5 per cent) was observed after irradiation. Studies of the *in vitro* N'-MeNA synthesis in liver homogenates revealed that synthetic activity decreased by 19.0 per cent in irradiated rats killed 1 hour later. Addition of ATP or glutathione to the reaction medium could not restore the diminished N'-MeNA synthesis, suggesting that the immediate fall in the synthesis of N'-MeNA was probably due to impairment of the enzymes involved in this methylation process. *In vitro* N'-MeNA synthesis at 20 and 24 hours after x-irradiation, however, was increased by 32.2 and 52.8 per cent respectively. This was corroborated by *in vivo* studies, which showed 40.5 per cent rise in N'-MeNA synthesis in x-irradiated rats. The evidence presented seems to indicate that in addition to the radiochemical degradation of methionine, the acceleration of transmethylation processes may be responsible for the lowering of methionine levels in x-irradiated animals. (auth)

## 16558

NORMAL STRUCTURE OF SPERMATID NUCLEI AND CHANGES CAUSED BY IONIZING RADIATION. Dennis Lacy and Joseph Rotblat (Saint Bartholomew's Hospital Medical Coll., London). Intern. J. Radiation Biol. **2**, 218-26 (1960) Apr. (In English)

Spermatid nuclei, at a certain period of their development, was examined both in normal cells and in those which were irradiated with a dose of 10,000 rad using 14 Mev electrons. Within normal nuclei we have identified two main components: a nuclear matrix and chromosomes. The chromosomes consist essentially of a chromosomal matrix of low electron density and microfibrils. The latter are about 25 Å thick and are coiled. The gyre-width and pitch of such coils is about 100 Å and 75 Å, respectively. Throughout much of the chromosomes the microfibrils are apparently arranged in the form of an open network in which some semblance of a hexagonal pattern can some-

times be discerned. In some regions the microfibrils are extremely numerous and closely packed together to form multi-stranded units. Such regions stain positively by the Feulgen technique. Coiled microfibrils also occur in the nuclear matrix. Three days after irradiation some nuclei superficially appear to be only slightly damaged. However, the number of coiled microfibrils of normal size and appearance is reduced. Thicker microfibrils are present. The over-all thickness of many of these microfibrils is about 200 Å. As a working hypothesis it is suggested that high doses of radiation cause the finer (25 Å) microfibrils to break, fuse and recoil. Similar observations were made on nuclei which show more obvious signs of damage. However, in such nuclei a large comparatively clear region occurs. The way in which this may arise is discussed. (auth)

## 16559

EFFECT OF X-RAYS ON THE DEVELOPMENT OF THE INFECTIVE LARVAE OF OESOPHAGOSTOMUM RADIATUM (RUD. 1803) (STRONGYLIDAE: NEMATODA). R. F. Riek and R. K. Keith (Commonwealth Scientific and Industrial Research Organization, Yeerongpilly, Queensland, Australia). Nature **186**, 981-2 (1960) June 18.

Calves reared worm-free were given either normal infective larvae or irradiated larvae of Oesophagostomum radiatum. These helminths often cause gastrointestinal infestation in cattle. The irradiated larvae were exposed to 20,000 r of x radiation. Calves from the group given irradiated larvae were killed and examined for worms 3, 4, 5, 6, and 8 weeks after infestation. A calf from the control group was killed 6 weeks after infestation. Results from examinations for worms are tabulated. The main effect of this level of radiation was to prevent the establishment of an adult male population in normal numbers. Findings are discussed. (C.H.)

## 16560

STIMULATING EFFECTS OF NUCLEAR RADIATIONS ON DEVELOPMENT AND PRODUCTIVITY OF RICE PLANTS. Maung Mya Thaung (Union of Burma Atomic Energy Center). Nature **186**, 982-3 (1960) June 18.

A stimulating effect was demonstrated for low levels of both beta and gamma radiation on the growth and productivity of rice plants. A varietal difference was observed in the reaction to an equal dose of the same kind of nuclear radiation. Plants grown from seed exposed to 1,000 r x radiation showed differences in height, but not in productivity, when compared with plants grown from unirradiated seed. (C.H.)

## 16561

THE INACTIVATION OF  $\alpha$ -CHYMOTRYPSIN BY IONIZING RADIATIONS. J. A. V. Butler and A. B. Robins (Royal Cancer Hospital, London) and J. Rotblat (St. Bartholomew's Medical Coll., London). Proc. Roy. Soc. (London) **A256**, 1-14 (1960) May 31.

The inactivation of  $\alpha$ -chymotrypsin by low-voltage x rays and by 15 Mev electrons was studied over a range of concentrations extending from the solid enzyme to dilute solutions and the sensitivity  $D_{37}/c$ , where  $D_{37}$  is the dose required to cause inactivation to 37% of the original at concentration  $c$ , determined under varied circumstances. The sensitivity is constant in air over a wide range of concentrations, but in the solid state is greater by a factor of about 7. That the enhanced sensitivity in the solid state is connected with disorganization of the secondary structure is shown by the fact that after partial inactivation by irradiation the enzyme is more sensitive to inac-

tivation by heating. This view is also supported by the finding that oxygen has no significant effect on the irradiation (with 15 Mev electrons) in the solid state, since there is no reason to expect that oxygen will influence the breaking of hydrogen bonds within the molecule. The sensitivities of the protease and esterase activities of the enzyme are the same, showing that only one kind of active centre is involved. The sensitivity also decreases at low concentrations of the enzyme. That this is not due to recombination of the radicals is shown by the finding that the effect is uninfluenced by varying the dose rate of the electron beam over a very wide range. An enhanced sensitivity is, however, observed in solutions from which the oxygen has been removed. It follows that secondary radicals, principally  $O_2H$ , formed in the presence of oxygen are less effective than the primary radicals. Kinetic equations are deduced which represent the main features of this behavior. A possible reason for the greater effectiveness of  $H$  than  $O_2H$  is the ability of the former to penetrate into the protein molecule. It was also found that in dilute solutions containing oxygen the electron beam is more effective than the x rays. This could be accounted for if equilibrium between the primary radicals and oxygen is not reached at the very high dose rates at which the electron pulses are delivered. In vacuo no differences in sensitiveness to the x rays and the electrons were observed. (auth)

## 16562

THE EFFECTS OF X-RAYS ON THE UPTAKE OF RADIOACTIVE SULPHATE. R. C. Curran (St. Thomas's Hospital Medical School, Eng.). Proc. Roy. Soc. (London) B152, 410-17 (1960) June 14.

Radioactive sulphate was used to determine the effects of x rays on the uptake of sulphate by the various tissues of the mouse in vivo and by calf costal cartilage in vitro. Sulphate uptake proved uniformly radioresistant in mice after a short time, but decreased with irradiation in cartilage. The effects of various protective substances were tested on cartilage. Only nitrogen and l-cysteine protected; some enhanced the radiation effect. (auth)

## 16563

BIOCHEMICAL EFFECTS OF INTERNAL IRRADIATION. Charles C. Irving and Jesse D. Perkinson, Jr. (Univ. of Tennessee, Memphis). Radiation Research 12, 597-606 (1960) June.

Intraperitoneal doses of 5.0, 3.0, and 0.5  $\mu$ c of  $P^{32}$  per gram of body weight significantly inhibited the oxygen consumption of rat liver slices. The liver  $Q_{O_2}$  was depressed 23% at 24 hours after injection of 5.0  $\mu$ c of  $P^{32}$  per gram and was depressed to lesser extent at the lower doses of  $P^{32}$ . The anaerobic glycolysis of rat liver slices was inhibited also after injection of 5.0  $\mu$ c of  $P^{32}$  per gram of body weight, the maximum inhibition of liver  $Q_{CO_2}^{N_2}$  being 60% at 24 hours after the administration of the  $P^{32}$ . The inhibition of glycolysis was not due to a lack of intracellular substrate, since liver glycogen was increased at 24 hours after injection of 5.0  $\mu$ c of  $P^{32}$  per gram of body weight. The same dose of  $P^{32}$ , 5.0  $\mu$ c/gm, which inhibited oxygen consumption and anaerobic glycolysis had no effect on liver succinic dehydrogenase, cytochrome oxidase, fumarase, and phosphorylase activities. Pyruvate oxidation and pyruvate utilization were also normal in the livers of the irradiated animals. (auth)

## 16564

RADIATION-INDUCED CHANGES IN SUSCEPTIBILITY OF SUBSTRATES TO ENZYMIC DEGRADATION. S. Okada, R. Kraunz, and E. Gassner (Univ. of Rochester, N. Y.). Radiation Research 12, 607-12 (1960) June.

Irradiation with  $\gamma$ -rays rendered albumin and hemoglobin more susceptible to tryptic digestion and cellulose more susceptible to the action of cellulase. The enzymatic susceptibilities of starch and casein were not affected greatly by irradiation. The increase in enzymatic susceptibility of albumin induced by irradiation was due to a decrease of the Michaelis-Menten constant and not to a change in the reaction constant. After  $\gamma$ -irradiation of isolated nuclei of rat liver, the deoxyribonucleic acid became more susceptible to the action of nonirradiated deoxyribonuclease. (auth)

## 16565

THE MECHANISM OF UNCOUPLING OF OXIDATIVE PHOSPHORYLATION IN RAT SPLEEN AND LIVER MITOCHONDRIA AFTER WHOLE-BODY IRRADIATION. Thomas L. Benjamin and Henry T. Yost, Jr. (Amherst Coll., Mass.). Radiation Research 12, 613-25 (1960) June.

Data are presented which show that whole-body irradiation of 800 r depresses the P:O ratio of mitochondria isolated from spleen and liver 24 hours after radiation. The action of the radiation is shown to be indirect. These data indicate that the mode of action is activation of the pituitary, with subsequent activation of the thyroid and the adrenal cortex. Inactivation of the spleen-phosphorylating mechanism is the result of overproduction of thyroxine; inactivation of the liver-phosphorylating mechanism is the result of overproduction of adrenal cortical steroids. The mechanism of action and the specificity of action are discussed in relation to the radiosensitivity of the spleen and the liver and the degree of radiation protection which they afford. (auth)

## 16566

DAMAGE AND RECOVERY OF MOUSE TESTIS AFTER 1000 r ACUTE LOCALIZED X-IRRADIATION, WITH REFERENCE TO RESTITUTION CELLS, SERTOLI CELL INCREASE, AND TYPE A SPERMATOGONIAL RECOVERY. Bernard R. Nebel and Carol J. Murphy (Argonne National Lab., Ill.). Radiation Research 12, 626-41 (1960) June.

After 1000 r of acute localized irradiation many spermatocytes are blocked in first metaphase. Many restitution nuclei similar to those seen after colchicine treatment form between the first and the tenth day after irradiation, the maximum being observed at 6 days. These restituted cells often drift toward the basement membrane. In agreement with previous investigators we have seen an excess number of Sertoli cells in heavily damaged tubules. This excess is not explained by cell division as shown by autoradiography, nor by shrinkage of tubules, since the number is abnormally high even after correction for the shrinkage. A major part of this excess apparently corresponds to the number of restitution cells formed from the blocked first metaphases. The ultimate fate of these indifferent "Sertoli"-like cells is unknown. We have not observed them entering a new spermatogenic cycle. Type A spermatogonia were observed between 8 and 10 days after 1000 r with a frequency of 0.007 per tubule. After division, the resulting daughter cells distribute themselves along the basement membrane, soon forming a complete ring of dividing spermatogenic cells, observed at 20 days in recovering tubules. Stage "XII" was observed at 5 weeks showing development only through first metaphase spermatocytes. The present findings appear to explain the discrepancies introduced by workers in the 1920's and not resolved since. (auth)

## 16567

REACTION OF LIMB REGENERATES OF ADULT AXOLOTL (SIREDON MEXICANUM) TO X-IRRADIATION.

V. V. Brunst (Roswell Park Memorial Inst., Buffalo). Radiation Research 12, 642-56(1960) June.

Axolotls belong to the Urodela group of amphibia which also includes newts and salamanders. This group is able to restore limbs, tail, and portions of the head after injury or amputation. As a result of contraction of muscles and constriction of blood vessels, bleeding stops shortly after amputation. The initial epidermal healing of the wound is accomplished by migration of epidermal cells or by migration of the epidermal layer from adjacent regions. A comparison was made of the effects of x irradiation on different tissues and the mechanism of regression or resorption after irradiation. Data are tabulated and results discussed. (C.H.)

16568

THERMORESTORATION OF RADIATION DAMAGE IN DRY BACTERIAL SPORES. R. B. Webb, E. L. Powers, and C. F. Ehret (Argonne National Lab., Ill.). Radiation Research 12, 682-93(1960) June.

Heating dry spores of Bacillus megaterium after anaerobic irradiation without an intervening exposure to air results in a substantial decrease in radiation sensitivity of the spores. This phenomenon, termed thermorestoration, appears to be caused by annealing of long-lived x-ray-induced states which damage the spore through a reaction with oxygen. This annealing proceeds in a simple exponential fashion with time at any given temperature, and rate constants for a number of temperatures were obtained. The annealing constant for thermorestoration varies from about  $1.0 \text{ min}^{-1}$  at  $99^\circ\text{C}$  to about  $0.0003 \text{ min}^{-1}$  at  $1^\circ\text{C}$ . The apparent energy of activation is  $15,890 \pm 460 \text{ cal}$ ; this value clearly differentiates the phenomenon from the small effect of temperature observed during irradiation in this system over the very much larger temperature range of  $-145^\circ\text{C}$  to  $35^\circ\text{C}$ . The ratio of inactivation constants at any two temperatures below  $35^\circ\text{C}$  is not changed by thermorestoration, although the numerical values of the constants may be changed by as much as 50%. Also, the transition temperature, below which radiation sensitivity is independent of the temperature during the irradiation, at about  $-145^\circ\text{C}$ , is not changed by thermorestoration. (auth)

16569

EFFECTS OF X-IRRADIATION OF SPONTANEOUS AND EVOKED BRAIN ELECTRICAL ACTIVITY IN CATS. H. Gangloff and Thomas J. Haley (Univ. of California, Los Angeles). Radiation Research 12, 694-704(1960) June.

Specific alterations in spontaneous and evoked brain electrical activity were demonstrated in cats receiving 400 or 200 r of WBR or 400 r localized to the head or body. Results obtained in unrestrained cats with electrodes in the cortex and subcortex are reported. (C.H.)

16570

HYPOTHERMIA AND ISCHEMIA OF THE BONE MARROW AS PROTECTION AGAINST INJURY BY WHOLE-BODY X-IRRADIATION IN RATS. Edgar J. Martin (Univ. of Toronto). Radiation Research 12, 705-9(1960) June.

Rats were given whole-body x irradiation while the hind legs of the experimental animals were tied and immersed in ice water. The findings suggest combined hypothermia and ischemia of the hind legs during irradiation protected elements of the bone marrow which later contributed to the recovery of the animals from the radiation insult. (auth)

16571

RADIATION-INDUCED CONDITIONED AVOIDANCE BE-

HAVIOR IN RATS, MICE, AND CATS. D. J. Kimeldorf, J. Garcia, and D. O. Rubadeau (U. S. Naval Radiological Defense Lab., San Francisco). Radiation Research 12, 710-18(1960) June.

Association of a distinctive taste stimulus with exposure to x rays results in a conditioned aversion toward the stimulus in rats, mice, and cats. This is manifested by a progressive reduction in the amount of flavored fluid consumed during a series of x-ray exposures and subsequently by the acquired value of the flavored fluid to act as a conditioned stimulus for aversive behavior in the absence of radiation. Saccharin-flavored water was effective as a conditioned stimulus for rats and mice, and chocolate-flavored milk was effective for cats. Some implications of these observations for the study of behavior are discussed. (auth)

16572

THE HISTOCHEMICAL EFFECTS OF X-IRRADIATION UPON SPLEEN AND LYMPH NODES. Ju-ting Chang (Inst. of Experimental Medicine, Chinese Academy of Medical Sciences, Peking). Sci. Sinica (Peking) 9, 671-86(1960) May. (In English)

The spleens and cervical lymph nodes from mice exposed to a single dose of 500 to 800 r x radiation were removed at periods varying from one hour to forty-five days post-irradiation. The tissues were analyzed for nucleic acids, acid and alkaline phosphatase activity, glycogen content, and sulphydryl groups. The nucleic acids content began to drop 8 hours after irradiation, the acid phosphatase activity increased markedly after irradiation, the alkaline phosphatase activity increased slightly after irradiation. The sulphydryl groups decreased immediately after irradiation, mainly owing to the change of erythrocytes in the spleen. There was no change in sulphydryl content of the lymph nodes. The immediate and marked decrease of sulphydryl groups in spleen is attributed to a series of processes including the ionization of water molecules in the tissue into oxidizing agents. The degree and duration of the histochemical changes were in proportion to the x radiation dosage used. 51 references. (C.H.)

16573

Karolinska Mediko-Kirurgiska Institutet, Stockholm. SOME ELEMENTARY EFFECTS OF IONIZING RADIATION. A. Forssberg. p.17-28 of "Health Physics in Nuclear Installations Symposium, Risø, May 25-28, 1959." (In English)

The theories of direct and indirect mechanisms in radiobiological research are discussed. Studies of radiation effects on the nucleoprotein of viruses suggested how the mechanism of cellular damage may work. Particular aspects of the action of radiation on mammals are discussed in terms of genetic effects, leukemia, shortened life span, aging, tumor occurrence, and sensitivity of sex cells and the embryonic stage. The actions of certain chemicals, administered prior to irradiation, toward protecting against radiation damage and the recovery of mice from radiation damage are discussed. (B.O.G.)

## Radiation Sickness

16574 JPRS-2592(p.1-11)

THE PROPERDIN SYSTEM IN ACUTE RADIATION SICKNESS. A. A. Bagdasarov, I. L. Chertkov, M. O. Raushenbach (Raushenbakh), N. L. Samoilina (Samoylina), and Z. I. Sheremet. Translated from Med. Radiol. 4, No. 4, 3-10 (1959). 11p.

This paper was previously abstracted from the original language and appears in NSA, Vol. 13, as abstract No. 15865.

**16575** JPRS-2592(p.100-7)

SPECIAL FEATURES IN THE POST-OPERATIVE PERIOD IN ACUTE RADIATION SICKNESS IN DOGS. A. N. Gamaleya, A. A. Gyurdzhian, A. F. Koskin, V. P. Nekrasov, and P. V. Simonov. Translated from Med. Radiol. 4, No. 4, 64-70(1959). 8p.

This paper was previously abstracted from the original language and appears in NSA, Vol. 13, as abstract No. 15876.

## CHEMISTRY

### General and Miscellaneous

**16576** ANL-6101

Argonne National Lab., Ill.

CHEMICAL ENGINEERING DIVISION SUMMARY REPORT [FOR] OCTOBER, NOVEMBER, DECEMBER 1959. Feb. 1960. 170p. Contract W-31-109-eng-38. OTS.

Chemical-Metallurgical Processing. A direct-cycle pyrometallurgical fuel-processing plant is being constructed in conjunction with EBR-II. The gamma-irradiation testing of the 175-watt white fluorescent mercury vapor lamp was continued to an integrated exposure of  $2 \times 10^9$  rad. Irradiation tests of Shell APL grease were completed, and the estimated useful life of this grease in the Air and Argon Cells is 2 and 3 years, respectively. Tests of the three types of d-c motors used in the operating manipulator of the Argon Cell indicate an expected useful cell operating life of 2 to 3 years. Continued irradiation tests of mineral-insulated cable show no catastrophic breakdown of the electric insulation even after an accumulated gamma dose of  $8.4 \times 10^9$  rad. The scheme currently under consideration for processing melt-refining residues involves a reduction of skull oxides by a solution of Mg in liquid Cd. Molten salt fluxes had variable effects on the rate of oxide reduction in dilute Mg systems. Work was continued on development of processes for EBR-II blanket materials. A large-scale metal-distillation unit to demonstrate metal distillation at rates up to 100 kg/hour is under construction. Two medium carbon steel thermal-convection loops were built and operated to ascertain the extent of corrosion under adverse thermal conditions. Data were obtained for the solubilities of V, Fe, and Ni in liquid Cd at temperatures from 400 to 650°C. Corrections were made to data on the solubility of Th in liquid Zn. Solubilities of U in Si-free Zn-Mg solutions were found to be significantly higher than when silicon was present. The peritectic temperature in the U-Cd system was found to be  $474 \pm 1^\circ\text{C}$ . The activity coefficient of U in Al at 4.8% U and  $686^\circ\text{C}$  is estimated to be  $1.25 \times 10^{-3}$ , based on a distribution coefficient of U between Cd and Al and the activity coefficient of U in pure Cd. The free energy of formation of  $\text{UPb}_3$ , determined by galvanic cell measurements, varied between -14.8 to -10.0 kcal/mole at temperatures of 400 to  $800^\circ\text{C}$ . Oxygen and fluorine bomb calorimetry are being used to obtain heats of combustion and heats of formation for sulfur and fluorine compounds of such elements as Mo, W, B, and Zr. Fuel Cycle Applications of Volatility and Fluidization Techniques. Several schemes involving the volatility of  $\text{UF}_6$  were proposed for processing irradiated fuels. These include a direct fluorination process, the Aqueous Dissolution Fluorination (ADF) Process and the Fused Fluoride Volatility Process. The Direct Fluorination Process involves direct fluorination of

oxide-matrix fuels with fluorine or other fluorination agents to produce volatile  $\text{UF}_6$  and  $\text{PuF}_6$ . Additional studies were made in the Fused Salt Fluoride Volatility Process for the recovery of U from U-Zr-matrix fuels. Additional studies of a one-step fluid-bed process for the conversion of  $\text{UF}_6$  to  $\text{UO}_2$  were made in the newly installed 3-inch Monel reactor. Reactor Safety. The program to clarify the factors governing the pyrophoric characteristics of the metals U, Zr, Th, and Pu was continued with studies of ignition phenomena and the combustion process. Reactor Chemistry. The determination of cross sections of  $\text{U}^{238}$  with neutrons from the Van de Graaff is reported. A two-step alkaline-permanganate procedure was developed for room-temperature decontamination of stainless steel surfaces. Transportation of decontamination reagents using foaming techniques is being investigated. (For preceding period see ANL-6068.) (W.L.H.)

**16577** GEAP-3208

General Electric Co. Vallecitos Atomic Lab., Pleasanton, Calif.

METAL-WATER REACTIONS. V. THE KINETICS OF METAL-WATER REACTIONS—LOW PRESSURE STUDIES. Sydney C. Furman. July 31, 1959. 72p. Contract AT(04-3)-189. OTS.

A technique was developed for the purpose of studying the kinetics of metal reactions with water vapor at low partial pressures of  $\text{H}_2\text{O(g)}$ . The details of the method were worked out in the study of the reaction of sodium and water vapor and adapted to work involving zirconium and aluminum alloys. Sodium investigations were made at 200 to  $350^\circ\text{C}$  and water vapor concentrations up to 400 ppm in a moving stream of helium carrier gas at a total pressure of one atmosphere. Studies involving zirconium and Zircaloy-2 were conducted at temperatures up to  $1700^\circ\text{C}$  and water vapor concentrations up to 30,000 ppm in one atmosphere He. The results of these experiments can be explained on the premise that the rate of reaction is controlled by the transport of water vapor through the helium. Good agreement was obtained between experimental results and calculations employing mass transfer considerations. A short study of aluminum was made at 900 to  $1400^\circ\text{C}$  with water vapor concentrations up to 6400 ppm. It was concluded from the essentially quantitative reduction of water vapor and the appearance of powdered oxide in the system that a vapor phase reaction between aluminum and water vapor occurred. (auth)

**16578** NYO-2932

[Massachusetts Inst. of Tech., Cambridge].

THERMODYNAMIC, SPECTRAL AND STRUCTURAL STUDIES OF COMPLEX IONS. Annual Report. Mar. 15, 1960. 24p. Contract AT(30-1)-1965. OTS.

Research is reported on studies of  $[\text{CoF}_6]^{3-}$  and  $[\text{Fe}(\text{H}_2\text{O})]^{2+}$  ions, metal carbonyls, vibrational spectra of thionyl halides and dimethylsulfoxide, preparation of  $\text{CD}_3\text{I}$  using dimethylsulfoxide, sulfoxide complexes, phosphine oxide complexes, tetrahedral nickel(II) complexes, tetrahedral cobalt(II) complexes, tetrahedral copper(II) and silver(I) complexes, and  $\beta$ -diketone complexes. (W.L.H.)

**16579** TID-5875

Washington Univ., St. Louis.

THE EFFECT OF METAL IONS ON THE ALKALINE HYDROLYSIS OF ADENOSINE TRIPHOSPHATE (thesis). Gloria Forinas Torralba. Mar. 1960. 92p. OTS.

The effects of divalent metal ions on the alkaline hydrolysis of adenosine-5'-triphosphoric acid (ATP) have

been investigated. It has been shown that the catalytic effects of all the metal ions, with the exception of  $Zn^{++}$ , are quite in agreement with the results of Eigen's studies on metal sulfate solutions in which he used the techniques of relaxation spectrometry. The deviation of  $Zn^{++}$  from the relationship of Eigen's values to the catalytic activity of the divalent metal ions may be explained by the fact that under the alkaline conditions of hydrolysis, the most probable predominant ionic species are the dianionic zincate ions. Aside from this, the possibility also exists of the  $Zn^{++}$  ions forming a stable complex with the tetramethyl-diaminomethane buffer. It may be assumed that the rate-determining step in the hydrolysis reaction is the decomposition of the completely hydrated metal ion to form the active ATP-metal ion intermediate complex. It has been found that the catalytic activity of the divalent metal ions has no relation at all to the relative stability constants of the ATP-metal ion complexes reported by Alberty. (auth)

**16580** TID-5970

Yale Univ., New Haven.

THERMAL DIFFUSION IN NON-AQUEOUS SOLUTIONS (THE BENZENE-CYCLOHEXANE SYSTEM AT 25°) (thesis). Arthur David Payton, Jr. May 1960. 285p. Contract AT(30-1)-1375. OTS.

Thermal diffusion in the benzene-cyclohexane system was studied utilizing the pure Soret effect. The results compare qualitatively with the most reliable of the present theories for prediction of Soret coefficients. A Rayleigh interferometer and a Soret cell made of glass and silver were employed. Other phenomenological theories for the time-dependent and steady-state Soret diffusion experiments were reviewed. New phenomenological equations are presented for the isothermal decay of the mole fraction gradient present in the steady state. Experiments were performed on an aqueous potassium chloride solution and a solution of  $n$ -heptane in benzene. The results on the latter solution are again lower than the theoretical values, but literature values for the Soret coefficient and the theoretical values are in qualitative agreement. The results on the potassium chloride solution agree well with the literature values. The three parts of the complete experiment, the time-dependent run, the steady-state run, and the isothermal-decay run, provide an excellent check on the self-consistency of the experiment. For these two solutions, the first two parts agree to one per cent and the last part agrees with the first two within eight per cent. Diffusion coefficients, obtained from the first and last parts, are in fair agreement with the literature values. Some experiments were carried out in a new differential refractometer to determine the change of refractive index with mole fraction for non-aqueous solutions, necessary for the calculation of Soret coefficients. This instrument is based on a principle not utilized in conventional differential refractometers. (auth)

**16581** UCRL-9145

California. Univ., Berkeley. Lawrence Radiation Lab. DIFFUSION COEFFICIENTS IN MULTICOMPONENT SOLVENTS (thesis). John Thomas Holmes. Apr. 1960. 50p. Contract W-7405-eng-48. OTS.

The diffusion of toluene, in two-component hydrocarbon solvent mixtures, at very dilute concentrations and at constant temperature was studied by a stirred diaphragm cell technique. The diffusion coefficient-viscosity products, for the  $n$ -hexane- $n$ -tetradecane,  $n$ -hexane-cyclohexane, and cyclohexane- $n$ -decane solvent mixtures, were best correlated as a linear function of the solvent composition expressed in mole fraction. The latter solvent mixture gave a definite minimum in its diffusion coefficient-viscosity

product composition data, corresponding to a similar minimum in the viscosity versus composition data. An extensive study was made of the effect of free and forced convection resistances outside of the diaphragm. It was found that the mass transfer resistance external to the diaphragm was small (0.3 per cent of the total resistance at 350 rpm stirring speed) and was nearly a constant for all the fluids investigated. Under these conditions the cell constant exhibited negligible variation with fluid properties. (auth)

**16582** AEC-tr-4076

CHROMATO-POLAROGRAPHIC INVESTIGATIONS. XIII. ANALYSIS OF MIXTURES OF ALIPHATIC NITRO COMPOUNDS. Wiktor Kemula and Danuta Sybilska. Translated from *Chem. Anal. (Warsaw)* 4, 123-34(1959). 13p. JCL.

The chromatopolarographic method was used for separating the homologue nitroalkanes, based on reversed phase partition chromatography. It was found that the separation on the cellulose acetate proceeds not only by the partition process, but involves adsorption on the carrier also. The conditions and the procedure are given which make it possible to separate: nitromethane, nitroethane, 1-nitropropane, 1-nitro- $n$ -butane, 1-nitro- $n$ -pentane, and 2-nitro- $n$ -hexane. This separation can be performed also in the presence of 1,2-dinitropropane and 1,3-dinitropropane. It is suggested that this method can be used to separate higher members of this homologous series. Probably this analysis can be performed in the presence of other polynitrocompounds. The conditions and the course of quantitative analysis by both elution and frontal methods were described, and some examples of quantitative determinations were given. The elution method makes possible the quantitative determinations in all cases of qualitative separations of investigated compounds. The necessary amount of analyzed compounds varies from 0.2 to 0.8 mg. The error does not exceed 5%. (auth)

**16583** AEC-tr-4104

MAGNETIC SUSCEPTIBILITY OF COMPLEX COMPOUNDS OF TRIVALENT COBALT. V. I. Belova and Ya. K. Syrkin. Translated by Lydia Venters (Argonne National Lab.) from *Izvest. Sektora Platiny i Drug. Blagorod. Metal., Inst. Obshchel i Neorg. Khim., Akad. Nauk S.S.R.* 30, 109-19(1955). 15p. JCL or LC.

The magnetic susceptibility of a series of complex compounds of trivalent cobalt was measured. Some measurements were taken in the temperature range from 349 to 77°K. The data are tabulated. It was shown that in transition from hexamines to penta-tetra-tri- and diamines their diamagnetic susceptibility decreases. In some cases even a slight paramagnetism is observed. A decrease in the diamagnetism is connected with the accumulation of such electronegative groups, as  $Cl$ ,  $NO_2$ ,  $NO_3$  in the internal sphere. Hexanitrocobaltates of potassium, rubidium, cesium, and ammonium show a slight paramagnetism. The magnetic susceptibility of  $Na_3[Co(NO_2)_6]$  at room temperature is equal to zero. Hypotheses for explanation of the properties of the hexanitrocobaltates observed are suggested. There is no foundation to assume that there is one trivalence and one tetravalence cobalt atom. It is most probable that both cobalt atoms are equivalent. Seven electrons in motion in the field of two centers of cobalt and two centers of the group  $O_7^-$  ensure sufficient stability of the ion. (auth)

**16584** JPRS-2592(p.121-8)

THE USE OF CHEMICAL SYSTEMS FOR DOSIMETRY. I. (L.) K. Sokolova. Translated from *Med. Radiol.* 4, No. 4, 78-81(1959). 8p.

The basic advantages of chemical dosimeters for the

measurement of radioactivity are reviewed. Liquid, solid, and gaseous dosimeters are discussed in detail. (C.H.)

**16585** JPRS-2650

STUDY OF THE EFFECT OF MOLECULAR STRUCTURE ON THE VELOCITY OF THE IONIC AND ATOMIC REACTIONS OF ISOTOPE EXCHANGE. I. THE EFFECT OF ISOMERIZATION OF THE RADICAL AND OF THE INTRODUCTION OF A DOUBLE BOND ON THE RATE OF ISOTOPE EXCHANGE OF AN ALKYL HALIDE WITH HALIDE IONS. M. B. Neyman, V. B. Miller, and Yu. M. Shapovalov. Translated from Zhur. Fiz. Khim. 29, 892-7(1955). 10p. OTS.

The kinetics of isotope exchange of isopropylbromide and isopropylidide with ions of corresponding halides in 90% ethyl alcohol were studied. In another experiment, the kinetics of allyl bromide exchange with bromine ions were examined. It was found that the isomerization of alkyl radicals increases the energy of activation and retards the velocity of the isotope exchange halide reaction. The bromine allyl experiment showed that the double bond in the beta location in relation to halide increases the ionic isotope exchange. (J.R.D.)

**16586** UCRL-Trans-532(L)

CATALYTIC POLYMERIZATION OF ETHYLENE AND PROPYLENE. Ya. (Ia.) T. Eidus and K. V. Puzitskii. Translated from Uspekhi Khim. 23, 986-1026(1954). 69p. JCL or LC.

The difficulties of catalytic polymerization of ethylene and propylene in the presence of mineral acids, metal halide salts, alkali metals, and metal oxides are discussed. (C.J.G.)

**16587**

CONFIRMATION OF THE CATALYTIC DEUTERATION OF METHYL GROUPS OF p-XYLENE BY THE USE OF THE INFRARED AND NMR METHODS. Kozo Hirota, Hazime Kusumoto, and Tomiko Ueda (Osaka Univ.). Bull. Chem. Soc. Japan 33, 423-5(1960) Mar. (In English)

In order to confirm the deuteration of the methyl groups of p-xylene (catalyzed by nickel powder), infrared and nuclear magnetic resonance (NMR) spectroscopy were used. In the infrared spectra, three observed bands were ascribed to deuterated methyl groups and not to deuterated rings. NMR spectra indicated that deuteration proceeded more easily at the two methyl groups than at the ring and that it takes place step by step, i.e.,  $\text{CH}_3 \rightarrow \text{CH}_2\text{D} \rightarrow \text{CHD}_2 \rightarrow \text{CD}_3$ . (D.L.C.)

**16588**

THE COORDINATION CHEMISTRY OF THE ACTINIDES. Alan E. Comyns (Atomic Energy Research Establishment, Harwell, Berks, Eng.). Chem. Rev. 60, 115-46(1960) Apr.

A comprehensive survey is given of coördination compounds formed by the actinides with organic ligands, both in solid state and in solution. The review includes discussions of the complexes of actinium, thorium, uranium, protactinium, neptunium, and plutonium individually and americium and heavier actinides together. 584 references are cited. (B.O.G.)

**16589**

THE USE OF INFRARED SPECTRA IN STUDYING HYDROGEN EXCHANGE BETWEEN ACETONE AND DBr WHEN IN THE GASEOUS PHASE. B. A. Kuznetsov (Lomonosov Moscow State Univ.). Doklady Akad. Nauk S.S.R. 131, 605-8(1960) Mar. 21. (In Russian)

A substance with undivided HBr and  $\text{H}_2\text{O}$  combined with chemically active hydrogen (acetone) was investigated.

The design of the vacuum device for measuring acetone and DBr exchange is shown. The exchange was measured by the intensity lines at  $2400 \text{ cm}^{-1}$  (HBr),  $1872 \text{ cm}^{-1}$  (DBr),  $3000 \text{ cm}^{-1}$  (CH), and  $2100 \text{ cm}^{-1}$  (DC); the deuteron content of various measurements was averaged. Calculations of deuteron content were obtained with the expression for the isotopic equilibrium constant. The equilibrium constant was taken as equal to 0.85. Mass-spectroscopic analysis of the deuteron-containing acetone was in good agreement with theoretical data. Deuteron-saturated acetone was obtained after 8 exchange operations of 10 days duration each. (R.V.J.)

**16590**

STUDIES ON METASTABLE STATES OF PORPHYRINS. II. SPECTRA AND DECAY KINETICS OF TETRA-PHENYL-PORPHINE, ZINC TETRA-PHENYL-PORPHINE AND BACTERIO-CHLOROPHYLL. Lauri Pekkarinen and Henry Linschitz (Brandeis Univ., Waltham, Mass.). J. Am. Chem. Soc. 82, 2407-11(1960) May 20.

The flash technique used earlier to study the metastable states of chlorophyll was applied to tetraphenylporphine, zinc tetraphenylporphine, and bacteriochlorophyll in toluene and pyridine solution. The spectra all show a main band just below the Soret peak, as well as other regularities. The decay law is again  $-dC^*/dt = k_1 C^* + k_2 (C^*)^2 + k_3 (C^*) (C_g)$  ( $C^*$  = excited state;  $C_g$  = ground state). The respective rate constants for all the compounds are almost the same, except for a much faster first-order decay in bacteriochlorophyll. Little or no flash-bleaching is observed with the  $\text{Cu}^{2+}$ ,  $\text{Co}^{2+}$ , and  $\text{Ni}^{2+}$  complexes of tetraphenylporphine. (auth)

**16591**

THE QUENCHING OF TRIPLET STATES OF ANTHRA-CENE AND PORPHYRINS BY HEAVY METAL IONS. Henry Linschitz and Lauri Pekkarinen (Brandeis Univ., Waltham, Mass.). J. Am. Chem. Soc. 82, 2411-16(1960) May 20.

Lifetime measurements were made on triplet states of anthracene and porphyrins in tetrahydrofuran and pyridine solution containing various salts, and the bimolecular quenching constants were evaluated. Although the paramagnetic transition metals generally have rate constants near  $10^8 \text{ l. mole}^{-1} \text{ sec}^{-1}$ , that for  $\text{Mn}^{2+}$  is much lower ( $\sim 10^6$ ) and various strongly paramagnetic rare earth salts have constants smaller than  $5 \times 10^5$ . The addition of water frequently causes a sharp drop in the quenching constant, which may be correlated with changes in solvation indicated in the absorption spectrum. It is concluded that the quenching is not simply related to the paramagnetism of the salt, and a charge-transfer mechanism is proposed. (auth)

**16592**

SYNTHESIS OF AROMATIC DIBORONIC ACIDS. A. H. Soloway (Massachusetts General Hospital, Boston and Harvard Medical School, Boston). J. Am. Chem. Soc. 82, 2442-4(1960) May 20.

The preparations of several diboronic acids are described. The facile acylation of o-aminoboronic acids is observed and a possible mechanism is noted. (auth)

**16593**

THE REACTIONS OF 3-PHENYL-1-BUTYLAMINE-3-C<sup>14</sup> AND 3-p-ANISYL-1-BUTYLAMINE-3-C<sup>14</sup> WITH NITROUS ACID. Arthur W. Fort and Robert E. Leary (Univ. of Kentucky, Lexington). J. Am. Chem. Soc. 82, 2494-8(1960) May 20.

The diazotization of 3-phenyl-1-butylamine-3-C<sup>14</sup> in acetic acid gives 3-phenyl-1-butene, 3-phenyl-1-butyl acetate,

and diastereoisomeric 3-phenyl-2-butyl acetates. 3-p-Anisyl-1-butylamine-3-C<sup>14</sup> gives a similar product mixture. The secondary ester products of these reactions show extensive isotope-position rearrangement. The significance of these results is discussed. (auth)

## 16594

THE IMINE RADICAL AND THE THERMAL DECOMPOSITION OF HYDRAZOIC ACID. F. O. Rice and Thomas A. Luckenbach (Catholic Univ. of America, Washington, D. C.). *J. Am. Chem. Soc.* **82**, 2681-2 (1960) June 5.

Experiments were performed in which measured amounts of hydrazoic acid in a flowing system were thermally decomposed and the products passed over a liquid nitrogen cooled finger. All the products were collected and analyzed so that a complete mass balance was obtained. The imine radical is believed to be formed in the primary step  $\text{HN}_3 \rightarrow \text{NH} + \text{N}_2$ , but neither the mechanism of formation of ammonium azide nor the nature of the blue material is known; possibly a small fraction of the NH may reach the cold finger and form a colored polymer,  $(\text{NH})_n$ . (auth)

## 16595

REACTIONS OF FREE RADICALS WITH AROMATICS. III. ISOTOPE EFFECTS IN THE ARYLATION OF DEUTERATED BENZENES. THE MECHANISMS OF ARYLATION. Ernest L. Eliel, Seymour Meyerson, Zoltan Welvart, and Samuel H. Wilen (Univ. of Notre Dame, Ind.). *J. Am. Chem. Soc.* **82**, 2936-44 (1960) June 5.

Isotope effects were determined for the free-radical arylation and alkylation of benzene-d and of benzene-benzene-d<sub>6</sub> mixtures with a variety of peroxides. In most cases isotope effects calculated from product deuterium content are in excess of unity. The benzene-benzene-d<sub>6</sub> mixture recovered from a chlorophenylation experiment (product isotope effect 1.3) is, however, unchanged in isotopic composition, indicating that the addition of the chlorophenyl radical to benzene to form an arylcyclohexadienyl radical is not freely reversible under the conditions of arylation. The product isotope effect is, therefore, ascribed to a competition between arylcyclohexadienyl radicals which go on to product diaryl and radicals which are diverted into side products (such as dimers), this competition being subject to isotopic discrimination. DeTar and Long have shown that arylcyclohexadienyl radicals may disproportionate, at least in dilute solution, into arylbenzenes and arylidihydrobenzenes. In accordance with this it has now been shown that the apparent product isotope effect in biphenyl obtained from benzene-d and benzoyl peroxide in dilute solution is higher when the biphenyl is carefully separated from the dihydrobiphenyl than when the dihydrobiphenyl is allowed to be air-oxidized to biphenyl which becomes commingled with the primary biphenyl product. Biphenyl isolated under the latter circumstances contains biphenyl-d<sub>2</sub>, as expected. Biphenyl-d<sub>2</sub> is formed also in the decomposition of benzoyl peroxide in benzene-d in relatively concentrated solutions, indicating that even under these conditions some biphenyl is formed by disproportionation of the phenylcyclohexadienyl intermediate, followed by dehydrogenation, rather than by direct hydrogen loss from the intermediate radical. (auth)

## 16596

A NEW TYPE OF TETRAHEDRAL COMPLEX OF NICKEL(II). F. A. Cotton and D. M. L. Goodgame (Massachusetts Inst. of Tech., Cambridge). *J. Am. Chem. Soc.* **82**, 2967-8 (1960) June 5.

The preparation and properties are reported for two tetrahedral complex compounds of nickel(II),  $[(\text{C}_6\text{H}_5)_2\text{N}]$   $[(\text{C}_6\text{H}_5)_3\text{PNIBr}_3]$  and  $[(\text{n-C}_4\text{H}_9)_4\text{N}]$   $[(\text{C}_6\text{H}_5)_3\text{PNII}_3]$ . The prop-

erties given are electric conductance of solutions in nitromethane, magnetic moments of the solids, and visible spectra of the solutions. (D.L.C.)

## 16597

REFRACTIVE INDEX AND DISPERSION OF THE BENZENE-METHANOL SYSTEM. Scott E. Wood, Sidney Langer, and Rubin Battino (Illinois Inst. of Tech., Chicago). *J. Chem. Phys.* **32**, 1389-93 (1960) May.

The refractive indices of the benzene-methanol system were measured at 25°C at seven wavelengths in the visible region. The electronic polarizability of benzene, methanol, and carbon tetrachloride was calculated from the refractive indices of this system and those of the benzene-carbon tetrachloride system by use of the Böttcher equation. The data are then used to calculate the molar electronic polarizations of the carbon tetrachloride-methanol system which are found to be in good agreement with experimentally determined values. These results show that the electronic polarizabilities of the three components are independent of the composition and hence of the environment. The electronic polarizabilities of the three substances are found to follow a dispersion equation with only one term. (auth)

## 16598

CRYSTAL FIELD SPLITTING OF ENERGY LEVELS OF THULIUM ETHYLSULFATE. John B. Gruber and John G. Conway (Univ. of California, Berkeley). *J. Chem. Phys.* **32**, 1531-4 (1960) May.

The operator-equivalent method was employed to calculate the theoretical splitting of electronic energy levels  $^3\text{P}_2$ ,  $^1\text{D}_2$ ,  $^3\text{F}_2$ ,  $^3\text{F}_3$ ,  $^1\text{G}_4$ , and  $^3\text{H}_6$  in  $\text{Tm}(\text{C}_2\text{H}_5\text{SO}_4)_3 \cdot 9\text{H}_2\text{O}$ . Intermediate field corrections were made to  $\alpha$ ,  $\beta$ , and  $\gamma$ . A first-order perturbation treatment on  $\text{Tm}^{3+}$  ( $4f^{12}$ ) in  $\text{C}_{3h}$  symmetry, using crystal-field parameters  $A_2^0(r^2) = 13 \text{ cm}^{-1}$ ,  $A_2^0(r^4) = -80 \text{ cm}^{-1}$ ,  $A_2^0(r^6) = -32 \text{ cm}^{-1}$ , and  $A_6^0(r^6) = 300 \text{ cm}^{-1}$ , predicts the position of the crystal quantum states in reasonable agreement with experiment. (auth)

## 16599

KINETICS OF UNIMOLECULAR DECOMPOSITION OF EXCITED ALKYLAMINE IONS. William A. Chupka and Joseph Berkowitz (Argonne National Lab., Ill.). *J. Chem. Phys.* **32**, 1546-53 (1960) May.

The unimolecular reaction  $\text{RCH}_2\text{NH}_2^+ \rightarrow \text{R} + \text{CH}_2\text{NH}_2^+$  was studied for the n-alkylamines from ethyl- to n-heptylamine inclusive by a mass spectrometric technique. The intensity of the metastable ion produced in the above reaction was measured and used to determine the variation of the specific rate constant with the internal energy of the molecular ion. The results are compared with those predicted by various theories. The agreement of the data with the theories of Kassel and of Rosenstock is bad for the smallest molecules but improves with increasing number of oscillators in the molecule. Earlier evidence for intramolecular vibrational relaxation in the parent molecular ions is discussed in relation to the assumptions of Slater's theory. A simplified application of Slater's theory seems unable to explain all the data. (auth)

## 16600

MICROWAVE SPECTRA AND STRUCTURE OF  $\text{H}_3\text{SiCN}$  AND  $\text{D}_3\text{SiCN}$ . Norbert Muller and Ronald C. Bracken (Purdue Univ., Lafayette, Ind.). *J. Chem. Phys.* **32**, 1577-8 (1960) May.

The microwave spectra of  $\text{H}_3\text{SiCN}$  and  $\text{D}_3\text{SiCN}$  were examined in order to determine their structure, especially

the distance between Si and C,  $r_0(\text{Si-C})$ . The assumption was made that  $r_0(\text{C-N}) = 1.58 \text{ \AA}$ . The results were:  $r_0(\text{Si-H}) = 1.49 \pm 0.05 \text{ \AA}$ ,  $\angle \text{C-Si-H} = 107.5 \pm 2^\circ$ , and  $r_0(\text{Si-C}) = 1.847 \pm 0.005 \text{ \AA}$ . The latter value for  $r_0(\text{Si-C})$  is very close to that in  $\text{H}_3\text{SiCH}_3$ , 1.8668, and both are less than the sum of the Pauling covalent radii, 1.94  $\text{\AA}$ . The possibility of the Si-C bonds in both  $\text{H}_3\text{SiCN}$  and  $\text{H}_3\text{SiCH}_3$  acquiring the same amount of double bond character through resonance is discussed. (D.L.C.)

## 16601

APPEARANCE POTENTIAL STUDY OF TETRAFLUOROHYDRAZINE. E. Dan Loughran and Charles Mader (Los Alamos Scientific Lab., N. Mex.). *J. Chem. Phys.* **32**, 1578-9 (1960) May.

Measurements were made on the appearance potentials of tetrafluorohydrazine in order to determine the bond dissociation energy of the N-N bond,  $D(\text{F}_2\text{N-NF}_2)$ . Data are given for the appearance of  $\text{NF}_2^+$ ,  $\text{NF}^+$ ,  $\text{N}_2^+$ ,  $\text{F}^+$ ,  $\text{NF}^{2+}$ , and  $\text{N}^+$  ions, and fragmentation mechanisms are given for the production of  $\text{NF}_2^+$  and  $\text{NF}^+$ . From the data for  $\text{NF}_2^+$  and  $\text{NF}^+$ ,  $D(\text{F}_2\text{N-NF}_2)$  is found to be  $1.3 \pm 0.3 \text{ ev}$ . (D.L.C.)

## 16602

$\text{C}^{13}$  HYPERFINE SPLITTING IN BENZONITRILE NEGATIVE ION. Raymond L. Ward (Univ. of California, Livermore). *J. Chem. Phys.* **32**, 1592 (1960) May.

Potassium benzonitrile was prepared with and without 64% labeling of the nitrile group with  $\text{C}^{13}$ , and its electron spin resonance spectrum was studied at  $-50^\circ\text{C}$ . The hyperfine pattern in the spectrum for unlabeled benzonitrile ion consists of 10 resolvable lines over a range of about 20 gauss; splitting by  $\text{C}^{13}$  doubles all lines. Since the  $\text{C}^{13}$  splitting is 6.4 gauss, the spin density at the  $\text{C}^{13}$  nucleus is 0.051 compared to the hydrogen atom in its 1S state. A carbon spin density of 4.25 is estimated for a configuration  $2s(2p)^3$ . (D.L.C.)

## 16603

THE EFFECT OF COMPLEX-FORMATION BY PHOSPHINE OXIDES ON THEIR P-O STRETCHING FREQUENCIES. F. A. Cotton, R. D. Barnes, and E. Bannister (Massachusetts Inst. of Tech., Cambridge). *J. Chem. Soc.* 2199-2203 (1960) May.

The infrared spectra of trimethyl- and triphenylphosphine oxide and a number of their complexes with various transition-metal cations were examined. Complex-formation causes the P-O stretching frequencies to shift  $\sim 50 \text{ cm}^{-1}$  to lower values. Since a simple kinematic effect would raise the frequency, an explanation in terms of a lowering of the P-O bond order is proposed. (auth)

## 16604

PHOSPHINE OXIDE COMPLEXES. PART III. BIS(TRIPHENYLPHOSPHINE OXIDE)DINITRATO-COMPLEXES OF COBALT(II), NICKEL(II), COPPER(II), AND ZINC(II). E. Bannister and F. A. Cotton (Massachusetts Inst. of Tech., Cambridge). *J. Chem. Soc.*, 2276-80 (1960) May.

The nitrates of cobalt(II), nickel(II), copper(II), and zinc(II) coordinate with two mols. of triphenylphosphine oxide. The compounds  $(\text{Ph}_3\text{PO})_2\text{M}(\text{NO}_3)_2$  are non-electrolytes of very high thermal stability. The cobalt compound appears to be tetrahedral in the solid; for solutions in 1,2-dichloroethane the configuration is uncertain but the infrared spectra indicate co-ordination of  $\text{NO}_3^-$  via one oxygen atom and are in general accord with the findings of Gatehouse, Livingston, and Nyholm for other, generally less stable, nitrate complexes. (auth)

## 16605

NUCLEAR MAGNETIC RESONANCE SPECTRA OF SOME

FLUORINE-CONTAINING POLYMERS. R. E. Naylor, Jr. and S. W. Lasoski, Jr. (E. I. du Pont de Nemours & Co., Inc., Buffalo). *J. Polymer Sci.* **44**, 1-7 (1960) May.

High resolution nuclear magnetic resonance spectra were measured for the  $\text{F}^{19}$  resonance in some fluorine-containing polymers. These data show that the  $\text{F}^{19}$  resonance frequency depends on the electronegativity of the other substituents on the carbon atom, in a manner similar to that found for small molecules. The resonance frequency also is dependent on substituents attached to adjacent carbons in a way not easily explained by inductive effects. It is hypothesized that these latter shifts may be due to direct potential interaction. The above generalizations, together with other supporting evidence, were utilized to assign a small peak in the spectrum of polyvinylidene fluoride to a head-to-head structure. This structure is present to the extent of 8 to 10%. (auth)

## 16606

SIMPLE METHOD FOR THE MEASUREMENT OF SOME ISOTOPE EFFECTS IN CHEMICAL KINETICS BY RADIO-ISOTOPES. V. Santro (Università, Padua and Consiglio Nazionale delle Ricerche, Padua). *Nuovo cimento* (10) **15**, 865-72 (1960) Mar. 16. (In Italian)

The possibility of precise measurements of isotopic effects on the rate constants of bimolecular equilibrium reactions of the general kind  $\text{A}_2 + \text{B}_2 \rightleftharpoons 2 \text{AB}$  when one of the isotopes involved is radioactive is examined. The impossibility of the measurement by means of carrier-free isotopes is evaluated through the approximate expression. A method is proposed whose essential feature consists of carrying out the reaction of the radioactive species  $\text{AA}^* + \text{B}_2 \rightleftharpoons \text{AB} + \text{A}^*\text{B}$ , in the presence of relatively large amounts of  $\text{A}_2$ ,  $\text{B}_2$ , and  $\text{AB}$  in chemical equilibrium. If the measurement is performed as suggested, the required velocity constant can be calculated. An examination of errors shows that the magnification factors of the experimental errors on the measured quantities are sufficiently small to allow a significant comparison between experimental and theoretical results. (auth)

## 16607

NUCLEAR RECOIL IN CRYSTALLINE HEXACHLORIDE COMPLEXES OF TETRAVALENT IRIDIUM. W. Herr and K. Heine (Otto-Hahn-Institut, Mainz and Universität, Cologne). *Z. Naturforsch.* **15a**, 323-5 (1960) Apr. (In German)

The Szilard-Chalmers reaction in crystals of  $\text{Na}_2\text{IrCl}_6 \cdot 6\text{H}_2\text{O}$ ,  $\text{K}_2\text{IrCl}_6$ , and  $(\text{NH}_4)_2\text{IrCl}_6$  was investigated by paper electrophoresis. Several  $\text{Ir}^{192}$  recoil species could be separated, their number and relative abundance being different for the three salts. In neutron irradiated  $\text{Na}_2\text{IrCl}_6 \cdot 6\text{H}_2\text{O}$  six recoil species could be distinguished. On heating the crystals to  $123^\circ\text{C}$ , the original substance is regenerated only by some of the fragments. The reformation of the original compound (annealing) may be described by a first-order reaction. (auth)

## Analytical Procedures

## 16608 BAW-1091

Babcock and Wilcox Co. Research Center, Alliance, Ohio. LIQUID METAL FUEL REACTOR EXPERIMENT—SPECTROGRAPHIC METHODS FOR BISMUTH ANALYSIS. C. H. Anderson and D. W. Brown. Apr. 1960. 36p. Contract AT(30-1)-1940. OTS.

Development of a rapid operating control method for magnesium and zirconium that has been added as corrosion inhibitors to a circulating bismuth loop is described. A

rapid method of determining the amount of corrosion products in liquid bismuth is also reported. Magnesium and zirconium can be quickly determined in 10% (w/v) bismuth in 8N HNO<sub>3</sub> over a 100 to 600 ppm range (with respect to bismuth) through the use of a rotating disc technique. Standard deviations of 2.4% for the magnesium and 2.9% for the zirconium determination were observed. It was found that magnesium concentrations up to 10,000 ppm had no effect on the zirconium determination. Some corrosion products were determined by d-c arc excitation on an ignited bismuth oxide sample. Adequate precision was obtained and there was good agreement between the spectrographic and chemical iron and chromium determinations. Modifications to the basic methods were briefly investigated. (auth)

**16609** CF-52-9-170(Del.)

Oak Ridge National Lab., Tenn.

ANALYSIS OF URANIUM SOLUTIONS FOR Na. V. J. Reilly. Sept. 25, 1952. Decl. with deletions Dec. 1, 1959. 3p. OTS.

A comparison is presented of results obtained by flame-photometric procedure and spectrographic analysis of samples of UO<sub>3</sub> dissolved in HNO<sub>3</sub> with various known amounts of NaCl solution added. Results were calculated on the basis of parts per million of U. Results indicate flame-photometric procedures are probably satisfactory for analysis for Na, but results obtained using the spectrograph were found low. (W.L.H.)

**16610** CF-59-8-141

Oak Ridge National Lab., Tenn.

EVALUATION OF FLAME PHOTOMETRY FOR THE DETERMINATION OF ELEMENTS OF THE RARE-EARTH GROUP. Oscar Menis. Aug. 27, 1959. 20p. OTS.

Flame spectra are presented of all rare-earth elements, except cerium and promethium, and of the closely related elements, scandium and yttrium. The precise wavelength and relative spectral intensity of each line and band, as well as the band width of all bands, are tabulated. In addition, the major bands and lines of each element are listed separately, together with the  $\frac{1}{2}$ -band width of all bands. Also included in this tabulation are the relative spectral interferences of other elements of the group studied which interfere with the emissivity measurements of the bands and lines listed. The wavelengths of band crests and lines were fixed from spectral data recorded photographically with a prism spectrograph. The remaining spectral data are based on the spectra of the several elements which were recorded with a high-sensitivity, grating flame spectrophotometer. Operating conditions used in recording the spectra with the spectrograph and also with the flame spectrophotometer are given. Based on the spectra and spectral data presented herein, deductions can be made relative to the applicability and limitations of flame photometry in the estimation of scandium, yttrium, and rare-earth elements in mixtures thereof. Lanthanum, ytterbium, and neodymium can be determined without spectral interference by other elements of the group studied. For all other elements of the group, some spectral interference is encountered. Nevertheless, by judicious selection of wavelength, certain of the elements may be determined flame photometrically in the presence of many of the other elements of the group without serious interference. Two examples are cited. (auth)

**16611** Y-1295

Union Carbide Nuclear Co. Y-12 Plant, Oak Ridge, Tenn.

FLAME SPECTROPHOTOMETRIC DETERMINATION OF CALCIUM IN LEAD METAL. Roscoe E. Barringer.

Mar. 22, 1960. 19p. Contract W-7405-eng-26. OTS.

A flame spectrophotometric method for the determination of calcium in lead metal in the range of 0.02 to 0.1% was developed. The method requires a minimum of sample preparation and time. Measurement of the 554  $\mu\mu$  calcium emission provided a limit of error (0.95) of  $\pm 4.2\%$ . (auth)

**16612** UCRL-Trans-539(L)

DETERMINATIONS OF METAL IONS BY HEXAMMINE-COBALT(III) CHLORIDE AND SODIUM FLUORIDE (FIRST AND SECOND REPORTS). Yoshimasa Takashima. Translated from Nippon Kagaku Zasshi 79, 243-8(1958). 14p. JCL.

Scandium was precipitated quantitatively from solution at a pH of 3 to 4 by hexammine cobalt(III) chloride and sodium fluoride reagents. The effects of the presence of Co<sup>2+</sup>, Cu<sup>2+</sup>, Ni<sup>2+</sup>, Mn<sup>2+</sup>, Ti<sup>+</sup>, Be<sup>2+</sup>, Zn<sup>2+</sup>, Cd<sup>2+</sup>, Ti<sup>4+</sup>, Zr<sup>4+</sup>, and glass were investigated. It was found that scandium in excess of 0.5 mg could be determined to within  $\pm 3\%$  by the gravimetric method. In order to detect smaller quantities, a radiometric analysis method which used hexammine cobalt(III) chloride labeled with cobalt-60 was devised. Determinations attempted on 0 to 300  $\mu\mu$  of scandium indicated that if a polyethylene vessel were used in preparing the precipitate, determination was possible within  $\pm 10\%$  error. (M.C.G.)

**16613**

DIFFERENTIAL THERMAL ANALYSIS OF SOME YTTRIUM AND LANTHANON COMPOUNDS. S. L. Blum and E. A. Maguire (Raytheon Co., Waltham, Mass.). Am. Ceram. Soc. Bull. 39, 310-12(1960) June.

The oxides of Y, La, Nd, Sm, Gd, Dy, and Er and the oxalates of Y, La, Nd, Sm, and Gd were subjected to differential thermal analysis from room temperature to 1100°C. Phase changes in the oxides were difficult to detect because of the sluggishness of the conversions involved. Characteristic curves for decomposition of the oxalates were determined and compared with thermogravimetric data. (auth)

**16614**

CATION EXCHANGE SEPARATION AND SPECTROPHOTOMETRIC DETERMINATION OF MICROGRAM AMOUNTS OF RHODIUM IN URANIUM-BASE FISSIUM ALLOYS. J. O. Karttunen and H. B. Evans (Argonne National Lab., Ill.). Anal. Chem. 32, 917-20(1960) July.

Uranium is extracted with 30% tributyl phosphate in carbon tetrachloride from a nitric acid solution of the fissium alloy which contains uranium, molybdenum, ruthenium, palladium, and zirconium, and the raffinate is strongly fumed with perchloric acid. The solution is then passed through a Dowex 50W-X8 cation exchange resin. Palladium is eluted with 0.3M hydrochloric acid, and the rhodium is then eluted with 6M hydrochloric acid. Rhodium is determined spectrophotometrically with tin(II) chloride. (auth)

**16615**

RADIOCHEMICAL DETERMINATION OF RADIUM IN URANIUM MILLING PROCESS SAMPLES. Henry G. Petrow, Oscar A. Nietzel, and Michael A. DeSesa (National Lead Co., Inc., Winchester, Mass.). Anal. Chem. 32, 926-7(1960) July.

A carrier-free method is described for the determination of Ra<sup>226</sup> in mill tailings solutions and other liquid and solid samples from the uranium milling process. Radium is carried on lead sulfate to effect a separation from the bulk of the sample. Purification from other naturally radioactive nuclides is achieved by conversion of the lead sulfate to the carbonate, dissolution of the carbonate in

nitric acid, and selective precipitation of Pb and Ra from fuming nitric acid. The Ra is separated from the Pb by adsorption of the Pb on Dowex 1-X8 anion exchange resin from 1.8M hydrochloric acid. Radium is then determined by conventional alpha counting techniques. (auth)

16616

SPECTROPHOTOMETRIC DETERMINATION OF YTTRIUM WITH PYROCATECHOL VIOLET. J. P. Young, J. C. White, and R. G. Ball (Oak Ridge National Lab., Tenn.). Anal. Chem. **32**, 928-30(1960) July.

The yttrium-Pyrocatechol Violet complex has been utilized in the development of a sensitive method for the colorimetric determination of Y. The molar absorptivity of this complex is 25,900 at a wave length of 665  $\mu\text{m}$ . Its absorbance conforms to Beer's law up to a concentration of Y of 1.8  $\mu\text{g}$  per ml. Trace amounts of Y can be determined in the presence of the alkaline earths, Zn, Ni, and nitrate and sulfate without prior separations. When first separated by solvent extraction with tri-n-octylphosphine oxide, large amounts of Fe, U, Zr, Th, and Mo can also be tolerated. The rare earth elements, Sc, V, fluoride, and phosphate ions interfere. The coefficient of variation for the determination of Y by this method is 3%. (auth)

16617

DETERMINATION OF VERY SMALL QUANTITIES OF LEAD. Royal R. Marshall (Univ. of Chicago) and David C. Hess (Argonne National Lab., Ill.). Anal. Chem. **32**, 980-6(1960) July.

A procedure was developed for separating microgram quantities of Pb from rocks, stone meteorites, and iron meteorites, with minimum contamination. Lead is volatilized from samples typically containing less than 1 ppm. The powdered sample or piece of iron meteorite is placed in a graphite crucible, heated to as high as 1400°C by an induction heater. After condensation on a water-cooled quartz surface, the lead is further purified rapidly and simply by dithizone extraction. Concentrations are determined colorimetrically using  $\text{Pb}^{2+}$  tracer to determine yields, as well as by isotopic dilution. Correction for contamination is made by blanks treated in the same way as the samples. Mass spectrometric analysis by surface ionization has been improved for small samples by using boric acid and tantalum filaments. Isotopic ratios can be measured to within a few per cent with approximately 1- $\gamma$  quantities. Where possible, the results are compared to those of other methods of analysis. (auth)

16618

ANALYSIS OF NATURALLY LEACHED URANIUM-THORIUM ORE SAMPLES. APPLICATION OF PURE GAMMA SPECTROMETRY. P. W. De Lange (National Physical Research Lab., Pretoria). Anal. Chem. **32**, 1013-17(1960) July.

All the radiometric methods in use at present are reviewed and their applications in the analysis of leached ores are discussed. Possible errors encountered in radiometric analysis are summarized. Pure  $\gamma$ -spectrometry gives the best results for the concentration of  $\text{U}_3\text{O}_8$  and  $\text{ThO}_2$  in the worst cases of natural leaching. (auth)

16619

ERRORS IN THE TITRIMETRIC DETERMINATION OF URANIUM-235. Joseph Rynasiewicz, Rene F. Dufour, and David P. Stricos (General Electric Co., Schenectady, N. Y.). Anal. Chem. **32**, 1048(1960) July.

The oxidation of uranium(IV) to uranium(VI) has been found to account for a -5% bias noticed in the determination of  $\text{U}^{235}$ . This induced air-oxidation is believed to be

due to the  $\alpha$  and  $\gamma$  radiation associated with the various isotopes in combination with the catalytic effect of impurities. Following removal of the bulk impurities, 99.8% pure uranium has been assayed and 99.07% has been consistently reported. Solutions of 99.94% natural uranium ( $\text{U}^{238}$ ) were analyzed by the same titrimetric method and gave 99.75% uranium. Correcting for the slightly low assay for  $\text{U}^{238}$ , this gives the bias of -0.5 relative % for the titrimetric determination of  $\text{U}^{235}$ . (B.O.G.)

16620

GALVANIC CELL FOR DETERMINING OXYGEN IN GASES CONTAINING CARBON DIOXIDE. Karl Koyama (General Electric Co., Richland, Wash.). Anal. Chem. **32**, 1053-4(1960) July.

A continuous analyzer is described which provides immediate knowledge of the oxygen content in a carbon dioxide gas system, such as a reactor coolant system. The galvanic cell utilizes a cadmium anode, a silver cathode, and a saturated potassium bicarbonate electrolyte. The use of this electrolyte has proven satisfactory for recording low concentrations of oxygen in  $\text{CO}_2$ ,  $\text{CO}$ ,  $\text{N}_2$ ,  $\text{H}_2$ , He, and their mixtures. A long-term precision to better than  $\pm 2\%$  was obtained from operation on tank carbon dioxide. (B.O.G.)

16621

NEUTRON ACTIVATION ANALYSIS OF IODINE IN SILICON. Tadashi Nozaki, Hideo Baba, and Hidemaro Araki (Tokyo Univ.). Bull. Chem. Soc. Japan **33**, 320-9(1960) Mar. (In English)

A trace quantity of iodine in silicon was determined by neutron activation analysis. A chemical separation process, which involves potassium hydroxide fusion with potassium iodide as a carrier, was proved satisfactory by the use of  $\text{I}^{131}$  produced by the neutron irradiation of tellurium diffused in silicon. By this method, the iodine was converted into silver iodide ready for counting and weighing within an hour, with a yield exceeding 50%. When it is assumed that a counting rate of 100 cpm is enough for accurate detection of activities, the limit of detection is 0.002  $\mu\text{g}$  of iodine with a neutron flux of  $6 \times 10^{11} \text{ n/cm}^2 \text{ sec}$  and by the use of a  $2\pi$  counter. (auth)

16622

STUDIES OF THE ACTINIDES. I. DETERMINATION OF  $\text{Am}^{241}$  CONTENT IN PLUTONIUM BY SPECTROSCOPY OF THE  $\alpha$  AND  $\gamma$  RAYS. J. Malý, H. Kurzweilová, R. Lenk, and I. Peka (Czechoslovak Academy of Sciences, Prague). Collection Czechoslov. Chem. Communs. **25**, 1383-90(1960) May. (In German)

The method is described and results are given from a measurement of traces of  $\text{Am}^{241}$  in  $\text{Pu}^{239}$  by  $\alpha$  and  $\gamma$  spectroscopy in a natural mixture (0.032%  $\text{Am}^{241}$ , referred to Pu) and in a concentrated mixture (0.69 or 3.6%  $\text{Am}^{241}$ ). The work indicates the possibility of determining  $\text{Am}^{241}$  in Pu by  $\alpha$  spectroscopy in a minimum quantity of 0.02% and  $\gamma$  spectroscopy in quantities up to 0.001%. (tr-auth)

16623

QUANTITATIVE SPECTRAL ANALYSIS OF ISOTOPIC COMPOSITION OF ENRICHED URANIUM. A. R. Striganov, F. F. Gavrilov, and S. P. Efremov. Kernenergie **1**, 112-18(1958) Feb. (In German)

A photographic process was worked out for the spectral analysis of the isotopic composition of enriched U in the concentration range of 2 to over 90%  $\text{U}^{235}$ . For a wide range of concentrations a calibration diagram process was studied, and a procedure not involving standards was established. Further, it was established that foreign im-

purities in the sample studied did not affect the results of the analysis. It was also shown that the photographic method of spectral analysis is not only more exact than other methods (which had average quadratic errors of  $\pm 2.2\%$  and  $\pm 0.3\%$  in the range 4 to 90%) but is more advantageous in practicality of application and cost. (tr-auth)

16624

Argentina. Comisión Nacional de Energía Atómica, Buenos Aires.

DETERMINACION ESPECTROSCOPICA CUANTITATIVA DE TORIO EN MINERALES ARGENTINOS. Informe No. 28. (Quantitative Spectroscopic Determination of Thorium in Argentine Minerals. Report No. 28). Olga Brieux de Mandirola. 1960. 8p.

A direct-current arc method is given for the quantitative determination of thorium as  $\text{ThO}_2$  in monazites and thorites. A Hilger E-492 model quartz spectrograph with a 10 slip was used. The small graphite anode is loaded with a synthetic standard of  $\text{ThO}_2$  and  $\text{Ba}(\text{NO}_3)_2$ ; the cathode is spectrally pure graphite and the gap 2 mm. The burning times are 150 seconds at 10-15 Å and 120 s at 15-17 Å. During the first period most of the interfering elements (Pb, Dy, Tb, Ce, Pr, and U) distill; the plates are exposed during the second period and read with a microphotometer. The sensitivity of the method is 0.5%, the reproducibility attained  $-8.7\%$ . (auth)

## General Inorganic and Physical Chemistry

16625 AECU-4449

Rensselaer Polytechnic Inst., Troy, N. Y.

A STUDY OF COMPLEX IONS IN FUSED SALT SYSTEMS. Final Report. R. A. Osteryoung, J. D. VanNorman, and J. H. Christie. Sept. 17, 1959. 127p. Contract AT(30-3)-241. OTS.

Absorption spectrophotometric methods were used in a study of complex ion formation and acid-base reactions in fused chloride and nitrate systems. Several methods for the treatment of spectrophotometric data were investigated. The spectra of various chromium salts were determined in three nitrate melts and in fused lithium chloride-potassium chloride. In low solute concentrations in  $\text{LiNO}_3$ - $\text{KNO}_3$ ,  $\text{NaNO}_3$ - $\text{KNO}_3$ , and  $\text{LiCl}$ - $\text{KCl}$  melts, the species found was the chromate ion, while in molten  $\text{AgNO}_3$ , the species found was the dichromate ion. An explanation of these observations is put forward, and their significance discussed. Formation constants for lead-chloro and lead-bromo complexes were evaluated. The values obtained for the first two lead-chloro and lead-bromo complexes are 11.3, 3.6 and 13.3 and 6.0, respectively. Mass spectral studies of the gaseous products of the reaction between dichromate ion and nitrate ion in fused  $\text{NaNO}_3$ - $\text{KNO}_3$  showed that the reaction is of an acid-base type, involving formation of a nitronium ion which then reacts with nitrate ion to evolve dinitrogen pentoxide decomposition products. A number of qualitative experiments in fused salts involving acid-base reactions were performed, and their relation to oxidation-reduction processes in the fused salts is discussed. An analogy is drawn to a similar relation in aqueous solution. (auth)

16626 CF-57-6-42

Oak Ridge National Lab., Tenn.

THE REACTION OF ZIRCONIUM WITH URANIUM DIOXIDE. M. T. Robinson. June 11, 1957. Decl. Apr. 20, 1960. 12p. OTS.

An investigation of the causes of observed explosive reaction of zirconium-coated uranium dioxide on dissolution in nitric acid was conducted. It was concluded that such a reaction is to be expected. Possible but unconfirmed methods of alleviating the problem are suggested. (J.R.D.)

16627 DP-477

Du Pont de Nemours (E. I.) & Co. Savannah River Lab., Aiken, S. C.

REACTIONS OF HYDROGEN PEROXIDE AND ION EX-CHANGE RESINS. Elizabeth W. Baumann. Apr. 1960. 30p. Contract AT(07-2)-1. OTS.

The interaction of dilute aqueous  $\text{H}_2\text{O}_2$  and ion exchange resins was investigated. A mechanism of absorption and decomposition of  $\text{H}_2\text{O}_2$  on anion exchange resin is proposed. (auth)

16628 HW-64528

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

VOLATILIZATION OF CESIUM DURING CALCINATION AND HYDROLYSIS OF  $\text{Cs}_2\text{ZnFe}(\text{CN})_6$  PRECIPITATES. Donald G. Bouse and Wallace W. Schulz. Mar. 23, 1960. 6p. Contract W-31-109-Eng-52. OTS.

Experiments were performed to determine the extent to which cesium volatilizes during calcination and hydrolysis of  $\text{Cs}_2\text{ZnFe}(\text{CN})_6$  precipitates containing cesium-137. The losses during calcination and steam hydrolysis at 400 and 600°C were 0.9 and 1.3%, respectively. Procedures and results are discussed. (J.R.D.)

16629 NAA-SR-5045

Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.

THE FREE ENERGY, HEAT, AND ENTROPY OF FORMATION OF THORIUM OXYFLUORIDE. A. J. Darnell. June 1, 1960. 13p. Contract AT-11-1-GEN-8. OTS.

Thorium oxyfluoride,  $\text{ThOF}_2$ , decomposes at elevated temperatures to  $\text{ThO}_2(s)$  and  $\text{ThF}_4(g)$ . The equilibrium pressure of  $\text{ThF}_4$ , from the decomposition of  $\text{ThOF}_2$ , was measured in a Knudsen effusion cell from 1109 to 1286°K. The pressure of  $\text{ThF}_4$  from the decomposition reaction was found to be  $\text{Log } P_{(\text{atm})} = -17,630 \pm 370/T(\text{°K}) + 9.363 \pm 0.302$ . The free energy, enthalpy, and entropy of formation of  $\text{ThOF}_2(s)$  at 298°K were determined to be  $-371.2 \text{ kcal/mole}$ ,  $-389.6 \text{ kcal/mole}$ , and  $-62.0 \text{ cal/deg-mole}$ , respectively. (auth)

16630 NYO-8009

Princeton Univ., N. J.

SOME ELECTRON AND PROTON RESONANCE STUDIES IN HETEROGENEOUS CATALYSIS. John Turkevich, John Mackey, and W. H. Thomas. June 1, 1960. 31p. Contract AT(30-1)-1158. OTS.

For presentation at Second International Congress on Catalysis, Paris, July 3-10, 1960.

Electron spin resonance was measured for a graded set of carbons prepared by heating glucose to various temperatures from 350 to 950°C. The catalytic properties of these carbons for the ortho-para hydrogen conversion and hydrogen deuterium exchange was correlated with the number of free localized electrons on the one hand and the antiferromagnetic domain of interacting electrons on the other hand. Chemisorption of hydrogen on the carbon was detected by a study of the decrease of electron spin resonance and the appearance of proton resonance in the solid. Proton resonance was measured for water introduced into cavities of known structure and uniform size in a number of synthetic zeolites. The width of the proton resonance of the water which completely fills the cavity is determined by the chemical nature of the cation in the cavity and is related to

its binding to the site. Measurements were also made of the width of the hydrogen resonance line of a graded set of cracking catalysts of varying alumina silica ratio. It was found that the width of the resonance line had a maximum at a silica alumina composition normally associated with high acidity and cracking catalytic activity. (auth)

**16631** OOR-1747.2

Baylor Univ., Waco, Tex.

THE EFFECT OF ORGANIC COMPOUNDS ON THE CO-DEPOSITION OF HYDROGEN WITH NICKEL (thesis).

Jack R. Goodwin. Technical Report No. 1 [on] THE MECHANISM OF THE ACTION OF ORGANIC BRIGHTENING AGENTS IN ELECTROPLATING PROCESSES. Apr. 1960. 139p. OOR Project No. 1747. Contract DA-23-072-ORD-1056.

Causes of the maxima observed in the current-voltage curves for the oxidation of hydrogen at a black nickel electrode in basic solution and at a gray palladium electrode in basic and acidic solution are reported. Results of the effect of the addition of certain organic compounds to a Watts type bath are discussed. (auth)

**16632** UCRL-9079

California. Univ., Berkeley. Lawrence Radiation Lab. IONIC MASS TRANSPORT BY FREE CONVECTION TO HORIZONTAL ELECTRODES (thesis). Eugene Joseph Fenech. Apr. 1960. 81p. Contract W-7405-eng-48. OTS.

Electrodeposition of copper from acid copper sulfate solutions onto horizontal electrodes facing upward is employed to investigate the mechanism and rate of mass transport under free-convection conditions. Mass-transfer rates are obtained by limiting-current measurements, and the distribution of current densities over the electrode surface is examined. Solution properties (concentration, viscosity, and density) and geometry (shape and size) are varied between broad limits. A physical model involving two distinct types of free convection is postulated by which the effect of geometry on mass-transfer rates can be explained. (auth)

**16633** AEC-tr-3927(Pts. 1 and 2)

THE CHEMISTRY OF FLUORINE AND ITS INORGANIC COMPOUNDS. I. G. Ryss. Translated from a publication of the State Publishing House for Scientific, Technical and Chemical Literature, Moscow, 1956. (484p., Pt. 1, 376p. Pt. 2). OTS.

A monograph is presented on the chemistry of fluorine and its inorganic compounds. A description of the chemical, physical, and thermochemical properties, production methods, uses, and principal physicochemical and molecular constants are included. A comprehensive bibliography is given for each discussion of the compounds of an individual group of elements. (B.O.G.)

**16634** AEC-tr-4095

EXPERIMENTS OF N. S. KURNAKOV AND HIS FOLLOWERS IN THE FIELD OF CHEMISTRY OF FUSED SALTS. N. K. Voskresenskaya. Translated by Lydia Venters (Argonne National Lab.) from Uspekhi Khim. 21, 1086-95(1952). 15p. JCL or LC.

A review of the work of N. S. Kurnakov and his followers on fused salt chemistry is presented. It is noted that data on fusibility were obtained for more than 250 triple reciprocal systems by these workers. Methods of investigating reciprocal systems are examined, and other methods of examining salt equilibria are discussed. (J.R.D.)

**16635** NP-tr-433

CHARGE-EXCHANGE BETWEEN IONS AND ATOMS OF CESIUM. (Perezaryadka Ioniv i Atomiv Tseziyu). R. M.

Kushnir. Translated from Ukrain. Fiz. Zhur. 3, 788-95 (1958). 15p. OTS.

This paper was previously abstracted from the original language and appears in NSA, Vol. 13, as abstract No. 11400.

**16636**

THE CRYSTAL STRUCTURE OF  $Rb_2ThF_8$ . L. A. Harris (Oak Ridge National Lab., Tenn.). Acta Cryst. 13, 502-5(1960) June. (In English)

A preliminary survey of the system  $RbF$ - $ThF_4$  revealed the existence of a compound with the formula  $Rb_2ThF_8$ . Examinations with the polarizing microscope showed it to be uniaxial positive with indices of refraction:  $N_E = 1.494 \pm 0.003$  and  $N_0 = 1.472 \pm 0.003$ . Optical observations after quenching from 800 to 400°C revealed no phase changes and constant optical properties. Satisfactory agreement is shown between calculated and observed x-ray intensity distributions for this compound. (B.O.G.)

**16637**

THE VAPOR PRESSURE OF  $T_2O$ . M. M. Popov and F. I. Tazedinov. Atomnaya Energ. 8, 420-4(1960) May. (In Russian)

The results and method for determining the vapor pressure of 83.4 and 98.1 mole %  $T_2O$  at 12 to 95°C are described. The pressure of gaseous products from radiolysis and nuclear transformations was determined by a statistical method. The boiling points for  $HTO$  and  $T_2O$  were found at 100.8 and 101.6°C, the heats of evaporation at these temperatures is 9.9 and 10.1 kcal/mole, and the standard entropies are 19.3, and 19.0 e.u., respectively. (R.V.J.)

**16638**

PRODUCTION OF DIBORANE BY REDUCING BORON FLUORIDE ETHYL ETHERATE WITH CALCIUM HYDRIDE. V. I. Mikheeva, E. M. Fedneva, and V. I. Alpatova. Doklady Akad. Nauk S.S.R. 131, 318-20(1960) Mar. 11. (In Russian)

Boron trifluoride reduction by calcium hydride was analyzed as a new method for obtaining boron and calcium boride. The purpose of the experiment was to produce diborane by reducing boron trifluoride etherate by calcium hydride. Synthesis of diborane was achieved at temperatures near the etherate boiling point. Tabulated data show good yields of diborane. (R.V.J.)

**16639**

THE ROLE OF CHEMICAL REACTIONS IN THERMIONIC EMISSION. G. M. Panchenkov and A. M. Kolchin (Lomonosov Moscow State Univ.). Doklady Akad. Nauk S.S.R. 131, 357-9(1960) Mar. 11. (In Russian)

The results of experiments show that at relatively low temperatures, large concentrations of cesium, and thin emitter layers, the production of cesium ions by chemical reaction with the base-layer (heater) is the determining factor in emission. (R.V.J.)

**16640**

DETERMINATION OF ENTHALPY AND SPECIFIC HEAT OF BERYLLIUM OXIDE IN THE 1200-2820°K TEMPERATURE RANGE. V. V. Kandyba, P. B. Kantor, R. M. Krasovitskaya, and E. N. Fomichev (Khar'kov State Inst. of Measurements and Measuring Instruments). Doklady Akad. Nauk S.S.R. 131, 566-7(1960) Mar. 21. (In Russian)

The heat content and heat capacity of solid phase beryllium oxide (99.9% BeO) were determined in the range 1200 to 2880°K. The data on enthalpy at high temperatures show the melting point to be  $2820 \pm 9^{\circ}K$ , while the published data quoted  $2843 \pm 30$  and  $2793 \pm 30^{\circ}K$ . (R.V.J.)

## 16641

THE PREPARATION AND CRYSTAL STRUCTURE OF MO-LYBDENUM(III) FLUORIDE. D. E. LaValle, R. M. Steele, M. K. Wilkinson, and H. L. Yakel, Jr. (Oak Ridge National Lab., Tenn.). *J. Am. Chem. Soc.* 82, 2433-4 (1960) May 20.

$\text{MoF}_3$  was prepared by the reduction of  $\text{MoF}_5$  with molybdenum metal powder. X-ray and neutron diffraction showed the crystal structure of this compound to be of the rhombohedral  $\text{VF}_3$ -type, rather than the cubic  $\text{ReO}_3$ -type structure previously reported. (auth)

## 16642

PREPARATION AND X-RAY DIFFRACTION DATA FOR SOME RARE EARTH STANNATES Charles G. Whinfrey, Donald W. Eckart, and Arthur Tauber (U. S. Army Signal Research and Development Lab., Fort Monmouth, N. J.). *J. Am. Chem. Soc.* 82, 2695-7 (1960) June 5.

A series of eight rare earth stannates and yttrium stannate isostructural with pyrochlore was prepared by solid state reaction at elevated temperatures. The general formula for these compounds is  $\text{A}_2\text{Sn}_2\text{O}_7$  where A is Nd, Sm, Pr, La, Gd, Er, Eu, Yb, or Y. Lattice constants calculated from x-ray-powder-diffraction data are given. The lanthanide contraction is demonstrated. A linear relationship is developed between lattice constant and ionic radius. (auth)

## 16643

IMPROVED METHOD FOR THE GROWTH OF YTTRIUM-IRON AND YTTRIUM-GALLIUM GARNETS. J. W. Nielsen (Bell Telephone Labs., Inc., Murray Hill, N. J.). *J. Appl. Phys.* 31, Suppl. to No. 5, 51S-2S (1960) May.

Large single crystals of yttrium and rare earth iron garnets and yttrium and rare earth gallium garnets were grown from molten solutions of lead oxide and lead fluoride. The crystals are grown by slowly cooling melts from about 1260°C to near 950°C. Sample compositions are: for YIG, 8 mole %  $\text{Y}_2\text{O}_3$ , 22 mole %  $\text{Fe}_2\text{O}_3$ , 30 mole %  $\text{PbO}$  and 40 mole %  $\text{PbF}_2$ ; for YGaG, 5.8 mole %  $\text{Y}_2\text{O}_3$ , 14 mole %  $\text{Ga}_2\text{O}_3$ , 39.4 mole %  $\text{PbO}$  and 40.8 mole %  $\text{PbF}_2$ . This method provides crystals both large in size and of superior quality. Best results are obtained when the containing crucible is hotter near its top than at its base since nucleation is thereby reduced. (auth)

## 16644

PARAMAGNETIC RESONANCE OF  $\text{Yb}^{+++}$  IN ALUMINUM AND GALLIUM GARNETS. John W. Carson and Robert L. White (Hughes Research Labs., Culver City, Calif.). *J. Appl. Phys.* 31, Suppl. to No. 5, 53S-4S (1960) May.

The paramagnetic resonance spectrum of  $\text{Yb}^{+++}$  in gallium and aluminum garnets was observed at liquid nitrogen and helium temperatures. The components of the principal g tensor are 2.85, 3.60, and 3.74 in gallium garnet, and 2.47, 3.78, and 3.87 in aluminum garnet. In aluminum garnet, for a range of Yb concentrations (relative to Y) of from 2 to 0.1%, the line width varies linearly from 98 to 20 gauss. The longitudinal relaxation time  $T_1$ , for the same Yb variation, increases from 0.001 sec to 0.02 sec. (auth)

## 16645

MASS SPECTROMETRIC STUDY OF GASEOUS MOLYBDENUM, TUNGSTEN, AND URANIUM OXIDES.

G. DeMaria, R. P. Burns, J. Drowart, and M. G. Ingram (Univ. of Chicago). *J. Chem. Phys.* 32, 1373-7 (1960) May.

Partial pressures of the gaseous oxides  $\text{MoO}$ ,  $\text{MoO}_2$ ,  $\text{MoO}_3$ ,  $\text{WO}$ ,  $\text{WO}_2$ ,  $\text{WO}_3$ ,  $\text{UO}$ ,  $\text{UO}_2$ , and  $\text{UO}_3$  in the systems  $\text{Mo-Al}_2\text{O}_3$  and  $\text{U-Al}_2\text{O}_3$  were measured by mass spectrometric methods. The vapor pressure of uranium was

also determined. The reaction enthalpies derived from these measurements are:

Reaction	$\Delta H^\circ_f$ kcal/mole
$\text{MoO(g)} \rightarrow \text{Mo(g)} + \text{O(g)}$	$116 \pm 15$
$\text{MoO}_2(\text{g}) \rightarrow \text{Mo(g)} + 2\text{O(g)}$	$262 \pm 10$
$\text{MoO}_3(\text{g}) \rightarrow \text{Mo(g)} + 3\text{O(g)}$	$411 \pm 7$
$\text{WO(g)} \rightarrow \text{W(g)} + \text{O(g)}$	$154 \pm 10$
$\text{WO}_2(\text{g}) \rightarrow \text{W(g)} + 2\text{O(g)}$	$296 \pm 7$
$\text{WO}_3(\text{g}) \rightarrow \text{W(g)} + 3\text{O(g)}$	$443 \pm 7$
$\text{UO(g)} \rightarrow \text{U(g)} + \text{O(g)}$	$179 \pm 7$
$\text{UO}_2(\text{g}) \rightarrow \text{U(g)} + 2\text{O(g)}$	$340 \pm 7$
$\text{UO}_3(\text{g}) \rightarrow \text{U(g)} + 3\text{O(g)}$	$493 \pm 7$
$\text{U(s)} \rightarrow \text{U(g)}$	$126 \pm 5$

(auth).

## 16646

POTENTIAL ENERGY CURVES FOR LITHIUM HYDRIDE. Robert J. Fallon, Joseph T. Vanderslice, and Edward A. Mason (Univ. of Maryland, College Park). *J. Chem. Phys.* 32, 1453-5 (1960) May.

Potential energy curves for the  $\text{X}^1\Sigma^+$ ,  $\text{A}^1\Sigma^+$ , and  $\text{B}^1\Pi$  states of LiH were calculated from spectroscopic data by the Rydberg-Klein-Rees method. The results are in agreement with curves previously obtained by Crawford and Jorgensen and by Rosenbaum using different methods. As a check, the somewhat peculiar curve for the  $\text{A}^1\Sigma^+$  state has also been calculated for LiD, and agrees with the LiH curve to about one percent. The curves obtained theoretically by Karo and Olson for the  $\text{X}^1\Sigma^+$  and  $\text{A}^1\Sigma^+$  states are only in fair agreement with the experimental results. (auth)

## 16647

THERMAL CONDUCTIVITY OF HELIUM AND HYDROGEN AT HIGH TEMPERATURES. Normand C. Blais and Joseph B. Mann (Los Alamos Scientific Lab., N. Mex.). *J. Chem. Phys.* 32, 1459-65 (1960) May.

A steady-state hot wire method for measuring the thermal conductivity of light gases in the temperature range 1200 to 2100°K is described. In contrast to other methods, free convection currents and large temperature gradients occur; convection effects are shown to be negligible, and the experimental procedure for eliminating the large gradient effects is described. The thermal conductivity of helium is found to follow the equation  $\lambda \times 10^6 = 991 + 0.678(T-1200)$  cal/sec cm deg over the temperature range covered. That for hydrogen is  $\lambda \times 10^6 = 1434 + 1.257(T-1200)$  cal/sec cm deg. (auth)

## 16648

VIBRATIONAL FREQUENCIES OF ALKALI HALIDE DIMERS. II. BENDING, SYMMETRIC STRETCH, AND  $\text{B}_{1g}$  MODES. Joseph Berkowitz (Argonne National Lab., Ill.). *J. Chem. Phys.* 32, 1519-22 (1960) May.

Three of the normal vibrational frequencies of alkali halide dimers are calculated on the basis of the potential function for an ionic model. The results indicate that the out-of-plane bending mode may have a frequency almost as high as the in-plane stretching frequencies. A summary of the results of calculations for the six normal modes is presented. (auth)

## 16649

TRACER EXPERIMENTS ON THE REACTION OF  $\text{UH}_3$  WITH AQUEOUS ACID. Umesh Agarwala, J. B. Hunt, and H. Taube (Univ. of Chicago). *J. Chem. Phys.* 32, 1567-8 (1960) May.

The reaction of  $\text{UH}_3$  with  $\text{DCl}$  in  $\text{D}_2\text{O}$  was studied at  $\text{DCl}$  concentrations of 16 and 11 M. The results were: (1) In

16 M DCl, there was an initial violent reaction with the production of much gas and a red solution, presumably  $U^{3+}$ , followed by a much slower reaction which formed gas of ~20% of the total evolved gas and a solution with a green color characteristic of  $U^{4+}$ . (2) In 11 M DCl, a slow reaction continued over a period of weeks with the production of some gas and a solution containing  $U^{4+}$  and a residue with a composition approximating  $U_3O_4$ . The evolved gas was collected for both reactions (1) and (2) and analyzed for  $H_2$ , HD, and  $D_2$ . The relative ratio of  $H_2$ : HD:  $D_2$  for reaction (1) was 0.11:1:0.20 for the initial phase and 0.26:1:0.44 for the last phase; the ratio for reaction (2) was 9.6:1:9.0 for the first 5 days and 3.6:1:2.6 for the time interval of 8 to 21 days. The difference between the  $H_2$ : HD:  $D_2$  ratios in (1) and (2) is ascribed to the formation of an oxide film which prevents direct attack of  $D^+$  on  $UH_3$  in 11 M DCl and hence prevents formation of HD. In 16 M DCl, the oxide film is not formed, but the fact that all the hydride H is given off as gas (either as HD or  $H_2$ ) in (1) as well as in (2) indicates that  $D^+$  must attack the hydride at H sites on the surface. (D.L.C.)

## 16650

SOME OBSERVATIONS ON ATOMIC EXCHANGE IN NO. W. Spindel and Marvin J. Stern (State Univ., Newark, N. J.). *J. Chem. Phys.* **32**, 1579-81(1960) May.

The rate of exchange between  $N^{14}O^{18}$  and  $N^{15}O^{16}$ ,  $N^{14}O^{18} + N^{15}O^{16} \rightarrow N^{14}O^{16} + N^{15}O^{18}$ , was studied by mixing isotopically labeled NO gas samples and analyzing the m/e = 33 peak of the mixture after a short period of time with a mass spectrometer. Experiments were done under various conditions: (1) Mixing was done at a pressure of ~2 cm Hg and analysis carried out immediately; complete exchange equilibration was observed in the short time required for analysis, 15 to 30 sec. (2) Mixing was done at 60 to 100  $\mu$  Hg; analysis indicates that the exchange rate is 100 to 1000 times slower than at 2 cm Hg, the 33 peak increasing by only 3% in 10 min after mixing. (3) ~20  $\mu$   $O_2$  added to ~60  $\mu$  NO was found to increase the 33 peak fourfold in the first 5 min. (4) A mixture of ~90  $\mu$  gas samples was frozen by liquid  $N_2$  for several minutes, then revaporized; no increase in the 33 peak was observed, indicating that the dimer formed in solid NO does not have a square structure but a bent chain, O-N-N-O. (5) The exchange rate was observed to increase on cooling, perhaps due to the increased reaction rate of NO with  $O_2$  traces at low temperatures. (D.L.C.)

## 16651

SPECTRAL AND REACTIVITY DIFFERENCES OF TRANSITION METAL IONS IN  $H_2O$  AND  $D_2O$ . Jacob Bigeleisen (Brookhaven National Lab., Upton, N. Y.). *J. Chem. Phys.* **32**, 1583-4(1960) May.

The effects leading to spectral shifts and other differences of transition metal ions in  $D_2O$  and  $H_2O$  are discussed, with emphasis on the  $M(H_2O)_6^{2+}$  type. The greater strength of hydrogen bonds in  $D_2O$  makes cations less stable and complexed cations more stable in  $D_2O$  than in  $H_2O$ . If the lifetime of the complex is  $> 10^{-13}$  sec, the cation has a zero-point energy which will differ by  $7500 \text{ cm}^{-1}$  in  $D_2O$  and  $H_2O$ . A 1 to 4% change in zero-point energy is sufficient to explain the spectral shifts observed by Halpern and Harkness. The effects of vibrational frequency differences of the bonded water molecules in the hydrated metal cation in  $D_2O$  and  $H_2O$  are examined; the complex in which a water molecule has been replaced with an anion is more stable in  $D_2O$  than in  $H_2O$  by 340 cal/mole. A combination of some of these effects is involved in electron transfer reactions and may explain the reduced reaction rates observed for  $D_2O$ . (D.L.C.)

## 16652

STRUCTURE AND MAGNETIC PROPERTIES OF  $LiCuCl_3 \cdot 2H_2O$ . P. H. Vosso, L. D. Jennings, and R. E. Rundle (Iowa State Univ. of Science and Tech., Ames). *J. Chem. Phys.* **32**, 1590-1(1960) May.

X-ray and magnetic studies were carried out on  $LiCuCl_3 \cdot 2H_2O$ . The x-ray study, carried out on monoclinic crystals, gives lattice constants  $a = 6.078$ ,  $b = 11.145$ ,  $c = 9.145 \text{ \AA}$ ,  $\beta = 108^\circ 50'$  and a space group =  $P2_1/c$ . The structure indicates that a ground state triplet is to be expected, and the paramagnetism of the crystals down to 5.0°K supports the existence of such a triplet, the reciprocal of molar susceptibility vs. T curve approximating that expected for the triplet rather than those for the singlet or independent ions. The susceptibility is not reversible above 220°K. (D.L.C.)

## 16653

THE CALORIMETRIC DETERMINATION OF THE HEATS OF ADSORPTION OF OXYGEN ON EVAPORATED METAL FILMS. D. Brennan (Univ. of Liverpool); D. O. Hayward (Imperial Coll. of Science and Tech., London); and B. M. W. Trapnell (Denstone Coll., Uttoxeter, Staffordshire, Eng.). *Proc. Roy. Soc. (London)* **A256**, 81-105(1960) May 31.

A Beeck-type calorimeter was used to measure the integral heat of adsorption of oxygen on evaporated films of titanium, chromium, manganese, iron, cobalt, nickel, niobium, molybdenum, rhodium, palladium, tantalum, tungsten, platinum, and aluminium. The variation of the heat with the extent of the adsorption was also determined, except with palladium, platinum, and aluminium, for which the amounts of oxygen adsorption were too small to allow this to be done. The overall error is not more than  $\pm 5$  kcal/mole. The surface areas of the films were measured before and after an adsorption by the B.E.T. method; krypton isotherms at -196°C were used for this purpose. From these data, it was possible to estimate the number of atoms of oxygen adsorbed per surface metal atom. In most cases, this quantity, together with the heat of adsorption, can be related to the oxygen/metal ratios and the heats of formation of certain oxides; this observation is remarkable in view of the limited extent of the adsorption. In the cases of rhodium, palladium and platinum the adsorption stops short of a monolayer and is probably true chemisorption rather than oxide formation. For those metals on which oxide formation occurs, the decrease in heat of adsorption with increasing coverage is interpreted in terms of an increase in the oxidation number of surface metal ions by electron transfer within the adsorbed layer. Some theoretical correlations between the heat of adsorption and the atomic and the bulk properties of the species concerned were examined and found of little value; an empirical relation with the metallic radius is given. (auth)

## 16654

KINETICS OF ELECTROLYTIC HYDROGEN AND DEUTERIUM EVOLUTION. B. E. Conway (Univ. of Ottawa). *Proc. Roy. Soc. (London)* **A256**, 128-44(1960) May 31.

Calculations of the isotopic ratio of exchange currents ( $i_0$ ) for cathodic hydrogen and deuterium evolution were made for limiting cases, and the dependence of the ratio upon reaction mechanism is discussed. Experimental values of  $(i_0)_H/(i_0)_D$  were obtained for nickel, copper, silver, gold, platinized platinum, and palladium under conditions of high solution purity and cleanliness of electrode surface. Control experiments on the kinetics of hydrogen evolution at each of the above metals were also carried out. The isotopic ratios of exchange currents are discussed in terms of reaction mechanisms. The

calculations are improved by taking into account surface coverage by adsorbed hydrogen or deuterium. A series of new limiting values for the isotopic ratios of exchange currents is presented and assignments of rate-determining mechanism in cathodic hydrogen and deuterium evolution are suggested for several metals. (auth)

16655

ACTIVATION OF ALKALI-HALIDE MONOCRYSTALS BY THE METHOD OF THERMODIFFUSION FROM THE GASEOUS PHASE. N. E. Luschik and Ch. B. Luschik.

Trudy Inst. Fiz. i Astron., Akad. Nauk Eston. S.S.R. No. 11, 62-79(1960). (In Russian)

A method is described for preparing monocrystal alkali halide phosphors by heating the base material in a pyrex or quartz ampule in the vapor of the activator. Activator distribution along the crystal thickness was investigated by the absorption method. Advantages and disadvantages of the "diffusion from the gaseous phase" method are considered. (auth)

16656

ON THE DIFFUSION OF IONS OF IMPURITIES IN ALKALI HALIDE CRYSTALS. O. G. Mankin. Trudy Inst. Fiz. i Astron., Akad. Nauk Eston. S.S.R. No. 11, 80-90(1960).

(In Russian)

The diffusion of Ag and Cu ions in KCl, KBr, and KI is described. Diffusion coefficients and activation energies are compared with the corresponding characteristics of self-diffusion. On the basis of the data obtained, an assumption is made that diffusion takes place in the weakened places of the crystal lattice. (auth)

16657

THE ISOTOPE EFFECT IN THE ELECTROLYTIC TRANSPORT OF LITHIUM IONS IN SOLID LITHIUM SULFATE. Arnold Lundén (Chalmers Tekniska Högskola, Göteborg). Z. Naturforsch. 15a, 365(1960) Apr. (In German)

A column of  $\text{Li}_2\text{SO}_4$  at  $630^\circ\text{C}$  was exposed to a direct current. The cathode was molten zinc in which the Li released was dissolved. A gold anode was used. After the electrolysis the molten salt was slowly cooled, and mass spectrographic analyses were made of parts of the column. From the enrichment found, the mass effect was calculated to be  $-0.14 \pm 0.06$ . The self-diffusion coefficient was estimated as  $6 \times 10^{-5} \text{ cm}^2/\text{sec}$ . (J.S.R.)

16658

ION-ION RECOMBINATION. E. R. Wooding (The University, Sheffield, Eng.). p.89-93 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The rate at which ions of opposite charge diffuse is obtained by solving Smuluchowski's equation for diffusion in a field of force. The ions approach to within a distance where they can enter a bounded orbit and an ion or atom in the vicinity of the orbit influences the recombination coefficient. The resulting function is dependent on the degree of ionization. At low ionization it is similar to that obtained by Thomson at low pressures and changes to Jaffe's relationship with increasing pressure. (auth)

## Radiation Chemistry and Radiochemistry

16659 AD-231268

Quantum, Inc., Wallingford, Conn.

THE FORMATION OF NEW POLYMERS USING IONIZING

RADIATION. Quarterly Technical Report [for] March 12, 1959-June 12, 1959. R. F. Horan. 18p. Contract DA-44-009-ENG-3723.

The attempted radiation polymerization of fifteen chemical mixtures is reported. Combinations of various monomers with phosphonitrilic chloride and decaborane, and the irradiation of two organometallic compounds have produced nine polymers, copolymers, or mixtures. Four of these products are new, and five represent variations of stoichiometry and total dose received for the mixture, phosphonitrilic chloride + triallylcyanurate. The decomposition temperature of the products ranges between 500 and  $520^\circ\text{F}$ . In order to help illuminate the mechanism involved in the radiation polymerization of these compounds, IR data is reported for one of the mixtures. Problems involved in the interpretation of results are discussed. Future work will be devoted to the further elucidation of the chemistry and structure of some of the polymers already produced. Also an effort will be made to test some of the already produced polymers for structural strength values and properties at elevated temperatures. (auth)

16660 ARF-1145-2

Illinois Inst. of Tech., Chicago. Armour Research Foundation.

RADIATION INDUCED FLUORINATION OF NITRO-COMPOUNDS. Quarterly Progress Report No. 2 [for] September 1 to November 31, 1959. P. Y. Feng. Dec. 11, 1959. 9p. Contract DA-11-022-ORD-3046.

Mixtures of carbon tetrafluoride and nitrobenzene were irradiated with high-energy electrons and gamma radiation and then analyzed for fluorinated nitrobenzenes using gas chromatography. Meta-fluoronitrobenzene and several unknowns were detected, but ortho- and para-fluoronitrobenzene could not be detected because they were eluted together with the nitrobenzene peak. Several possible mechanisms for the radioinduced fluorination of nitrobenzene are discussed. (D.L.C.)

16661 NP-8696

Space Technology Labs., Inc. Physical Research Lab., Los Angeles.

FORMATION OF THIN POLYMER FILMS BY ELECTRON BOMBARDMENT. R. W. Christy. Dec. 17, 1959. 17p. (PRL-9-30).

Thin insulating films, less than 100 Å thick to a few thousand Å, were produced by bombarding a substrate with electrons in the presence of silicone oil vapor. The rate of deposition of the solid film was found to depend on the substrate temperature, electron beam current density, and oil vapor pressure. A theoretical expression for the rate is given, which agrees satisfactorily with the experimental data. The films which were produced had excellent electrical insulating properties. (auth)

16662

A UNIVERSAL  $\text{Co}^{60} \gamma$  RAY SOURCE WITH 60,000 g-eq Ra (K IS 60,000) FOR RADIOCHEMICAL RESEARCH. A. Kh. Breger, V. B. Osipov, and V. A. Gol'din. Atomnaya Energi. 8, 441-5(1960) May. (In Russian)

The design is given of an installation utilized in radiation chemistry and research. Various source configurations and magnitudes are available: cylindrical, two-plane, and single and multi-rod configurations; and dose rates from  $\sim 250$  to  $\sim 3000 \text{ r/sec}$ . The installation is suitable for a wide range of radiochemical research at arbitrary physico-chemical parameters. Remote control permits continuous observations of experimentation processes. (tr-auth)

16663

RADIATION-INDUCED POLYMERIZATION OF  $\alpha$ -

**METHYLSTYRENE.** Kozo Hirota, Kenji Makino, Keiji Kuwata, and Gisuke Meshitsuka (Osaka Univ.). Bull. Chem. Soc. Japan 33, 251-5 (1960) Feb. (In English)

It is shown that (a)  $\alpha$ -methylstyrene polymerizes at room temperatures by gamma irradiation; that (b) the reaction proceeds by a radical mechanism, considering the effect of solvents, additives, and ultraviolet light; that (c) ceiling temperature for this monomer is exceptionally low (ca. 70°C) compared with other vinyl monomers, so that it is hard to obtain high polymers by the usual method; and that (d) the experimental fact that the velocity of polymerization is proportional to dose rate and not to square root of dose rate can be explained by the assumption that degradative chain transfer occurs more frequently than the termination between active polymers. (auth)

16664

**EFFECT OF CUPRIC ION ON OXIDATION OF BENZENE AQUEOUS SOLUTION BY COBALT-60 GAMMA-RAYS.**

Hiroshi Hotta and Akira Terakawa (Japan Atomic Energy Research Inst., Tokyo). Bull. Chem. Soc. Japan 33, 335-7 (1960) Mar. (In English)

The effect of a cupric ion on the radiolysis of benzene aqueous solution can be interpreted by the following reactions of a cuprous ion produced in reaction  $\text{Cu}^{2+} + \text{H} = \text{Cu}^+ + \text{H}^+$ . That is, the larger yield of phenol than  $\text{G}_w(\text{OH})$  in the presence of oxygen is due to the increment of OH radical by reaction  $\text{Cu}^+ + \text{H}_2\text{O}_2 = \text{Cu}^{2+} + \text{OH}^- + \text{OH}$ , and no precipitation in the absence of oxygen is due to rehydrogenation by reactions  $\text{Ph} + \text{Cu}^+ = \text{Ph}^- + \text{Cu}^{2+}$  and  $\text{Ph}^- + \text{H}^+ = \text{PhH}$ , respectively. (auth)

16665

**THE USE OF RECOIL FISSION RARE GAS FOR THE STUDY OF THE CHANGE IN CRYSTAL STRUCTURE.** Seishi Yajima, Sumio Ichiba, Yuichiro Kamemoto, and Koreyuki Shiba (Japan Atomic Energy Research Inst., Tokyo). Bull. Chem. Soc. Japan 33, 426-7 (1960) Mar. (In English)

The use of recoil fission rare gas deposition in a solid for studies of crystal changes of the solid is described. In this method,  $\text{UO}_2$  powder is mixed with the solid powder to be examined (usually in the ratio of 1:30), the mixture is irradiated with thermal neutrons, and the resulting entrapped  $\text{Xe}^{135}$  is used to study changes in the solid structure.  $\text{UO}_2$  was mixed with  $\alpha$ - and  $\gamma$ -hematite and irradiated in this way, and after cooling for one day the mixture was heated slowly (5°/min) with helium flowing over it at a constant rate. Analysis of the outflowing helium for the  $\gamma$  ray of  $\text{Xe}^{135}$  gave a sharp peak for  $\gamma$ -hematite at 680°C, in agreement with x-ray diffraction data for the  $\gamma \rightarrow \alpha$  change, but none for  $\alpha$ -hematite. (D.L.C.)

16666

**LIBERATION OF CHLORINE IN RADIOLYSIS OF CARBON TETRACHLORIDE.** Z. Spurný (Czechoslovak Academy of Sciences, Prague). Collection Czechoslov. Chem. Commun. 25, 1254-7 (1960) May. (In German)

The production of free Cl in the x irradiation of  $\text{CCl}_4$  was studied. It was found that the Cl was produced in proportion to the radiation dose and the yield was not affected by the presence of  $\text{O}_2$  in the solution. The most probable mechanism for Cl production is discussed. (tr-auth)

16667

**ON THE INVESTIGATION OF THE INFLUENCE OF EXTERNAL RADIATION ON THE RATE OF THE ISOTOPIC EXCHANGE OF SULPHUR IN THE  $\text{K}_2\text{SO}_4-\text{SO}_3$  SYSTEM UNDER HIGH TEMPERATURE.** V. I. Spitzyn, I. E.

Mikhailenko, I. V. Vereshchinskii, and P. J. Glazunov (Inst. of Physical Chemistry, Academy of Sciences, USSR). Doklady Akad. Nauk S.S.R. 131, 360-3 (1960) Mar. 11. (In Russian)

Previous experiments indicated considerable influence of potassium sulfate specific radioactivity (with  $\text{S}^{35}$ ) on the rate of sulfur exchange in the  $\text{K}_2\text{SO}_4-\text{SO}_3$  gas system at 840°C. Further studies were made of the influence of radiation phenomena in the gaseous phase and on the salt. Isotopic exchange with low activity potassium was determined in  $\text{K}_2\text{SO}_4$  and  $\text{SO}_3$  vapors subjected to external irradiation by the electron beam from a betatron. The data show that external irradiation with  $10^{16}$  ev/10 min does not influence the rate of isotopic exchange. An increase of dose to  $10^{16}$  to  $10^{17}$  ev increases the rate of exchange in direct logarithmic proportion to the dose.  $\beta$ -particle emission by the radioactive preparation  $\text{K}_2\text{SO}_4$  produces a considerably greater influence on the rate of exchange. Electron irradiation of gaseous  $\text{SO}_3$  produces an activating effect. (R.V.J.)

16668

**SOME FEATURES IN THE RADIOLYSIS KINETICS OF n-HEPTANE WITHIN A WIDE RANGE OF DOSES.** V. G. Berezkin, I. M. Kustanovich, L. S. Polak, and N. Ya. Chernyak (Inst. of Chemical Synthesis of Petroleum, Academy of Sciences, USSR). Doklady Akad. Nauk S.S.R. 131, 593-6 (1960) Mar. 21. (In Russian)

The yield of various products of radiolysis was studied with irradiated hydrocarbon at 300°C and doses from 0.25 to  $28 \times 10^{21}$  ev. The yields of hydrogen, methane, and  $\text{C}_2-\text{C}_5$  fractions are plotted. The yields were (in molecules/100 ev):  $\text{H}_2$ , 4.5;  $\text{CH}_4$ , 0.2; saturated  $\text{C}_2-\text{C}_5$ , 1.6; unsaturated  $\text{C}_2-\text{C}_5$ , ~0.4; and fluid unsaturated compounds, 2.0. Yields of various fluid olefins and dienes are plotted as a function of dose. (R.V.J.)

16669

**THE EFFECT OF  $\gamma$ -RADIATION OF  $\text{Co}^{60}$  ON SACCHARA-ROSA SOLUTIONS.** M. A. Khonokh, E. A. Kuzicheva, and V. F. Evdokimov (Inst. of Cytology, Academy of Sciences, USSR). Doklady Akad. Nauk S.S.R. 131, 684-7 (1960) Mar. 21. (In Russian)

Previously it was shown that irradiation of monosaccharides, disaccharides, and high-molecular hydrocarbons induces oxidation and hydrolytic splitting. Further tests were made for determining the participation of the radiolysis products, OH,  $\text{HO}_2$ , and  $\text{H}_2\text{O}_2$ , in radiochemical changes of sucrose. The results show that each product produces a different chemical effect. (R.V.J.)

16670

**THE EFFECT OF MODERATORS ON THE REACTIONS OF HOT HYDROGEN ATOMS WITH METHANE.** Peder J. Estrup and Richard Wolfgang (Yale Univ., New Haven). J. Am. Chem. Soc. 82, 2661-5 (1960) June 5.

The reaction of recoil tritium with methane was examined in further detail. The previous hypothesis that this system involves a hot displacement reaction of high kinetic energy hydrogen to give  $\text{CH}_3\text{T}$ ,  $\text{CH}_2\text{T}^{\cdot}$  and  $\text{HT}$  is confirmed. The effect of moderator on this process is studied by the addition of noble gases. As predicted these gases inhibit the hot reaction, their efficiency in this respect being  $\text{He} > \text{Ne} > \text{Ar} > \text{Xe}$ . The data are quantitatively in accord with a theory of hot atom kinetics. The mechanism of the hot displacement process is briefly discussed. (auth)

16671

**KINETIC THEORY OF HOT ATOM REACTIONS: APPLICATION TO THE SYSTEM  $\text{H} + \text{CH}_4$ .** Peder J. Estrup and

Richard Wolfgang (Yale Univ., New Haven). J. Am. Chem. Soc. 82, 2665-9(1960) June 5.

A model was developed for the kinetics of hot atom reactions in the gas phase. An expression is derived giving the total probability that a hot atom will react before losing its excess energy, in terms of the average collisional energy loss and the efficiency of reaction upon collision. The model predicts the relative effect of inert moderating compounds and provides a measure of the relative energy at which various products are formed in reactions with a given substance. The theory is tested using experimental data on the action of moderators on the reactions of hot tritium with methane and is found to provide a good representation of this system. (auth)

#### 16672

EFFECTS OF NUCLEAR RECOIL IN THE CHROMIUM(III)-THIOCYANATE SYSTEM OF COMPLEXES. Sheldon Kaufman (Princeton Univ., N. J.). J. Am. Chem. Soc. 82, 2963-4(1960) June 5.

A dilute aqueous solution of  $(\text{NH}_4)_3\text{Cr}(\text{NCS})_6$ , containing no free  $\text{NCS}^-$ , was irradiated with a neutron flux in order to study the chemical effects of the recoil following the  $\text{Cr}^{50}(\text{n},\gamma)\text{Cr}^{51}$  reaction. The Cr-NCS system of complexes was selected because the rates of complex interconversion are slow. After irradiation, the solution was first passed through a cation-exchange resin column and then through a chromatographic column. In the first column, the radioactivity due to  $\text{Cr}^{51}$  was measured for each separated complex, while in the second column, total Cr was determined for each complex. There is no retention of radioactivity in  $\text{Cr}(\text{NCS})_6^{3-}$  and very little retention in any complex with more than two  $\text{NCS}^-$ . However, the major part of the total Cr is in  $\text{Cr}(\text{NCS})_6^{3-}$  and  $\text{Cr}(\text{NCS})_6^{2-}$ . The ratio of trans- to cis- $\text{Cr}(\text{NCS})_6^{2-}$  is 0.31 for both the radioactivity and the total Cr, as compared to the equilibrium value of 0.5 at 370°K. Two small unidentified peaks were observed in the first column elution curve and may be due to complexes with fragments of  $\text{NCS}^-$ . (D.L.C.)

#### 16673

ALPHA RADIOLYSIS OF CO WITH AND WITHOUT Xe. P. S. Rudolph and S. C. Lind (Oak Ridge National Lab., Tenn.). J. Chem. Phys. 32, 1572-3(1960) May.

The alpha radiolytic condensation of CO with and without xenon was studied in order to determine the effect of xenon. The reaction was followed by measuring the pressure (constant volume) and the fraction of radon decayed in the gas mixture, and then calculating the CO and  $\text{CO}_2$  pressures from the former on the basis of the equation,  $3 \text{ CO} \rightarrow \text{CO}_2^{+}$  solids. A plot of the logarithm of the CO pressure vs. fraction of radon decayed gave two approximately parallel lines for the cases with and without xenon; this parallelism indicates that xenon neither accelerates nor retards the reaction and hence has no effect. A possible explanation of this lack of an effect is given. (D.L.C.)

#### 16674

THE EFFECT OF QUINONES ON THE  $\gamma$ -IRRADIATION OF CYCLOHEXANE. E. S. Waight and P. Walker (Imperial Coll. of Science and Tech., London). J. Chem. Soc. 2225-30(1960) May.

The  $\gamma$ -irradiation of solutions of p-benzoquinone in cyclohexane results in the formation of quinol, 2,5-dicyclohexylquinol, and 2,5-dicyclohexylbenzoquinone. It is shown that the presence of quinone causes decreases in the G values (number of molecules per 100 ev) for hydrogen and bicyclohexyl production, but hardly affects the yield of cyclohexene. Irradiation of cyclohexane solutions

of p-toluquinone is also studied. Yields of cyclohexene and bicyclohexyl from irradiated cyclohexane in the absence of added solutes were confirmed by an isotopic dilution method. (auth)

#### 16675

THE SYNTHESIS AND IRRADIATION OF POLYBOROSILOXANES. R. L. Vale (United Kingdom Atomic Energy Authority, Wantage, Berks, Eng.). J. Chem. Soc. 2252-7(1960) May.

The preparation and properties of a series of condensation products of boric acid and organo-chlorosilanes are described. From the compositions and molecular-weight measurements a structure is proposed for the resulting polymers. Irradiation of the borosiloxanes induced a linking reaction, giving higher-melting materials with improved hydrolytic and heat stability. (auth)

#### 16676

USE OF NITROUS OXIDE TO DISCRIMINATE BETWEEN THE FORMS OF HYDROGEN ATOMS ( $\text{H}^0$  AND  $\text{H}_2^+$ ?) PRODUCED BY  $\gamma$ -IRRADIATION OF AQUEOUS SOLUTIONS. F. S. Dainton and D. B. Peterson (The University, Leeds, Eng.). Nature 186, 878-9(1960) June 11.

The radiation chemistry of aqueous solutions containing nitrous oxide was investigated to determine the forms of hydrogen atoms produced by  $\gamma$  rays. Some of the results for ferrous sulfate solutions are shown, from which it is evident that: (a)  $G(\text{F}^{3+})$  has the same value in the deaerated nitrous oxide-containing solution as in the nitrous oxide-free solution; (b) the total gas yield is the same in both systems and equal to  $G(\text{H}_2) + G(\text{H}_2^+)$ ; (c) in the  $\text{N}_2\text{O}$ -containing system some nitrogen is always produced and the ratio  $G(\text{N}_2)/G(\text{H}_2)$  increases slightly as the pH is increased to 2 and then rises sharply with further increases. The value of  $G(\text{N}_2)$  at pH > 2.7 is that expected on the hypothesis that all the available hydrogen atoms are scavenged by  $\text{N}_2\text{O}$  in a reaction of one mole of  $\text{N}_2$  for every mole of  $\text{H}_2$  scavenged. The fact that  $G(\text{N}_2)$  does not become zero at pH < 2 is interpreted as evidence for the existence of two different species of H atom, only one of which is capable of reducing  $\text{N}_2\text{O}$  in this low pH range. (B.O.G.)

## Raw Materials and Feed Materials

#### 16677 BMI-1193

Battelle Memorial Inst., Columbus, Ohio.

THE INFLUENCE OF LUBRICATION ON THE COMPACTABILITY OF MAGNESIUM-GREEN SALT BLENDS FOR BOMB REDUCTION. Stan J. Paprocki, Ronald J. Carlson, and Edward G. Smith, Jr. June 18, 1957. Decl. Mar. 31, 1960. 16p. Contract W-7405-eng-92. OTS.

Lubrication of die surfaces with mineral oil or Dag 217 during final compacting of  $\text{UF}_4$ -Mg blends prevented seizing. Mineral oil application after every third press allowed 18 compacts before seizing became severe. Similar application of Dag 217 allowed 78 compacts. Mixing 0.33 wt.% Ceremul "C" with the powder allowed 40 compacts. Punch clearance had little effect on seizing. (T.R.H.)

#### 16678 BMI-1225

Battelle Memorial Inst., Columbus, Ohio.

STUDIES RELATING TO HYDROGEN IN DINGOT URANIUM. Max J. Trzeciak and Manley W. Mallett. Sept. 20, 1957. Decl. Mar. 31, 1960. 32p. Contract W-7405-eng-92. OTS.

The distribution of  $\text{H}_2$  among feed materials and products in the thermite reaction producing dingot U was studied. The  $\text{H}_2$  content of Mg, molten U, and molten and solid  $\text{MgF}_2$

was measured over a range of temperatures. Degassing of dingot U at high temperatures and low pressures was investigated. (T.R.H.)

**16679** HW-42995

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

URANIUM NITRATE CONVERSION. E. F. Curren. May 10, 1956. Decl. May 4, 1960. 16p. Contract [W-31-109-Eng-52]. OTS.

A step-by-step description of the UNH (uranyl nitrate hexahydrate) Conversion Process is given and flowsheets are contained. In the process, UNH is dehydrated and reduced to  $U_3O_8$ . (T.R.H.)

**16680** HW-45128

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

THERMAL DECOMPOSITION OF PLUTONIUM(IV)

OXALATE AND HYDROFLUORINATION OF PLUTONIUM(IV) OXALATE AND OXIDE. M. N. Myers. Aug. 1, 1956. Decl. Apr. 28, 1960. 30p. Contract W-31-109-Eng-52. OTS.

Decomposition of  $Pu(C_2O_4)_2 \cdot 6H_2O$  occurs slowly at 21 to 25°C. Thermal decomposition in an inert atmosphere occurs stepwise: loss of 5 $H_2O$  at 80°C, loss of the other  $H_2O$  at 150 to 160°C, decomposition to  $Pu_2(C_2O_4)_3$  at 160 to 200°C, decomposition at 260 to 275°C, resulting in  $PuO_2$  at 500°C. Oxygen increases the decomposition rate. Plutonium(IV) oxalate may be fluorinated directly to  $PuF_4$  by anhydrous  $HF-O_2$  at 500°C. Optimum conversion (90% in one hour with 0.1 cm cakes) is obtained by calcination of  $Pu(C_2O_4)_2$  to  $PuO_2$  below 480°C and fluorination at 500°C. (T.R.H.)

**16681** KY-230

Union Carbide Nuclear Co. Paducah Plant, Ky.

ADDITIONAL STUDIES ON RECOVERY OF URANIUM HEXAFLUORIDE FROM VENT GASES. W. R. Gollher, G. H. Connor, T. J. Mayo, and W. Rossmassler. Oct. 10, 1957. Decl. Mar. 31, 1960. 16p. Contract W-7405-eng-26. OTS.

Data are presented on the recovery of low concentration  $UF_6$  with a fluidized bed of  $UF_4$  at 400°F. It was found that essentially 100% of the  $UF_6$  may be recovered in the concentration range 100 to 4000 ppm  $UF_6$  in the presence of 2 to 3%  $F_2$ . Data are given for the "adsorption" capacity of  $UF_4$  for  $UF_6$ . (auth)

**16682** LA-1854

Los Alamos Scientific Lab., N. Mex.

SPECIFIC SURFACE AND BULK DENSITY OF  $U_3O_8$  AND  $UO_2$  AS FACTORS IN  $UF_4$  PRODUCTION ON THE 250 GRAM URANIUM SCALE. R. J. Bard, O. E. Fry, and R. W. Kewish. Dec. 1954. Decl. May 13, 1960. 26p. Contract W-7405-eng-36. OTS.

Specific surface and bulk density measurements were made on samples of 22  $U_3O_8$  materials prepared by calcination at 900°C of widely differing uranium peroxide precipitates. Specific surface and bulk density measurements were also made on samples of the 22 corresponding  $UO_2$  intermediates. The ranges of values encountered in the  $U_3O_8$  samples and in the  $UO_2$  samples were 0.05 to 0.37  $m^2/g$  and 0.03 to 0.33  $m^2/g$ , respectively, for specific surface and 3.7 to 1.8  $g/cm^3$  and 4.9 to 2.7  $g/cm^3$ , respectively, for packed bulk density. Specific surface varied inversely with packed bulk density for  $U_3O_8$ , the data showing a good correlation. A very poor correlation between specific surface and packed bulk density of  $UO_2$  was obtained. The conversion of  $U_3O_8$  to  $UF_4$  in the standard process varied from 22% for the lowest specific surface, highest bulk

density oxide to 98 to 99% for the high specific surface, low bulk density oxides. The observed values for properties of the  $U_3O_8$  samples correlated better with conversion of  $U_3O_8$  to  $UF_4$  than did the observed values for properties of the corresponding  $UO_2$  intermediates. (auth)

**16683** MCW-1372

Mallinckrodt Chemical Works, St. Louis.

PROCESS DEVELOPMENT QUARTERLY REPORT.

PART II. W. M. Leaders. Feb. 1, 1955. Decl.

Mar. 31, 1960. 170p. Contract W-14-108-Eng-8. OTS.

Data are presented from pilot plant studies of U extraction using diluted tributyl phosphate; the effects of agitation on the efficiency of the plant extraction column; pilot plant studies on a proposed process for U recovery from slag which will reduce the U content of discarded slag and the fluoride content of the product U cake; the effect of hydration prior to reduction and hydrofluorination during the production of  $UF_4$  from  $UO_3$ ; the reduction of  $UF_4$  with Mg in a refractory-lined bomb and the effects of using Ca or Mg as a source of extra heat during hot-wire ignition; the fabrication of improved slag liners for use with dingots; the development of improved techniques for U casting; and the reduction of  $UF_4$  in steel bomb shells lined with magnesium fluoride slag. (For preceding period see MCW-1371.) (C.H.)

**16684** MCW-1382

Mallinckrodt Chemical Works, St. Louis.

PROCESS DEVELOPMENT QUARTERLY REPORT.

PART I. Jan. 3, 1956. Decl. Mar. 31, 1960. 129p.

Contract W-14-108-Eng-8. OTS.

Progress is reported on raw material, metal quality, and new refinery projects. Various aspects of the green salt process were studied. Metallographic techniques were applied to follow the effects of fabrication practices on metal structure. A tracer method for determining the retention times in green salt reactor tubes was developed. Analytical developments included studies of the quantitative reduction and automatic titration of U, the polarographic determination of U, and the spectrophotometric determination of hexene and tributyl phosphate in aqueous solutions. General conclusions are outlined. (W.L.H.)

**16685** MCW-1383

Mallinckrodt Chemical Works, St. Louis.

PROCESS DEVELOPMENT QUARTERLY REPORT. PART

II. Feb. 1, 1956. Decl. Mar. 31, 1960. 182p. Contract

W-14-108-Eng-8. OTS.

A study was made of the equilibrium relations in the butyl phosphate-hexane-uranyl nitrate-water systems and pilot plant operation of TBP-hexane cycle for uranyl nitrate purification. Continuous denitration of raffinate, U chip reprocessing, slag grinding, and development of improved techniques for U casting are reported. Work was continued on the dingot process and dingot forging, nuclear power fuel element improvement, and operation of green salt reactors at 360 lb/hr discharge rate. Magnesium fluoride grinding facilities and a study of ingot soundness are reviewed. (For preceding report see MCW-1381. For Part I of this report see MCW-1382.) (J.E.D.)

**16686** MCW-1393

Mallinckrodt Chemical Works, St. Louis.

PROCESS DEVELOPMENT QUARTERLY REPORT. PART

II. Nona McCalpin, ed. Aug. 1, 1956. Decl. Mar. 31,

1960. 114p. Contract W-14-108-Eng-8. OTS.

Pilot plant operation of a TBP-Hexane extraction cycle

for  $\text{UO}_2(\text{NO}_3)_2$  purification is reported. The control of  $\text{H}_2$  in dingot metal and improved techniques for U casting were investigated. Experimental 3500 lb dingot bomb reduction indicated that  $\text{UO}_3$  additions to the charge may improve metallic yields. Press forging procedures for  $\text{UO}_3$  fuel elements were revised. Ball milling MCW high-temperature-processed  $\text{UO}_2$  provided a moderate improvement in density without contamination. Flame fusion of  $\text{UO}_2$  powder, processing of unsulfated  $\text{UO}_3$ , U recovery from C-Liner material, and casting of blended charge using high C scrap were studied. (For previous period see MCW-1392.) (M.C.G.)

**16687 MCW-1397**

Mallinckrodt Chemical Works, St. Louis.

PROCESS DEVELOPMENT QUARTERLY REPORT.

PART I. Nona McCalpin, ed. Oct. 1, 1956. Decl. Mar. 31, 1960. 206p. Contract W-14-108-eng-8. OTS.

Work was continued on raw material, extraction, green salt metal quality, and analytical projects. At equal nitrate concentrations, and in the absence of complexing anions, the salting power of five cations in the ethyl ether extraction of U is as follows:  $\text{Mg} = \text{Al} > \text{Fe} = \text{Li} > \text{Ca}$ . In U extraction with diethyl ether, V, Mo, or As tend to precipitate and will do so in the absence of insufficient complexing agents. The extraction factor for U is unaffected by these elements, and the precipitation can be prevented by the presence of ferric iron. The experimentally determined decontamination factor for Th in the ether extraction process for U is much lower than the calculated factor. It is still adequate for purifying feeds containing 2% Th, to meet the 50 ppm Th specification in the product. The rates of mass transfer for U and Th in TBP extraction are similar. Oxidation of the  $\text{Cl}^-$  in a stream trapped from the  $\text{HNO}_3$  concentrator column appears to be the most practical method of controlling chloride-induced corrosion in the column. Permanganate is the best oxidant studied. The economics will be compared to ozonation in the near future. Reactivity ratios for  $\text{UO}_3$  determined by the K-25 Reactivity Test, are in qualitative agreement with plant performance of the  $\text{UO}_3$ , but quantitative correlation was not established. With other conditions constant, the +100 mesh fraction of high temperature ( $\sim 1450^\circ\text{F}$ ) reduced  $\text{UO}_2$  is appreciably less reactive than the smaller fractions. This is consistent with observations on the effect of  $\text{UO}_3$  particle size on the hydrofluorination rate of the  $\text{UO}_2$ . Hot slurry hydrated-dehydrated  $\text{UO}_3$  and amorphous  $\text{UO}_3$  produced in two different ways hydrofluorinated very much faster and more completely than pot denitrated  $\text{UO}_3$  regardless of the temperature of reduction. The resulting  $\text{UF}_4$  was not caked. Liner treatments which looked promising previously do not provide a completely effective means of producing low-hydrogen metal. Low-hydrogen metal can be produced in small bombs by purging the interstitial gas with He or Ar. This may be difficult to carry out on a large scale, and a combination treatment may be necessary. Excer Process green salt from Oak Ridge gave poor yields and poor quality metal based on small-bomb tests, presumably due to water and sulfate contamination. Fluidized bed green salt from Argonne did not mix well with Mg and gave poor yields; after ball-milling, however, its performance was satisfactory. Based on preliminary results, impurity removal by high temperature hydrofluorination of U concentrates will be incomplete. More study is indicated. New analytical methods were developed for both water (XIII) and  $\text{UO}_2\text{F}_2$ (XIV) in  $\text{UF}_4$ . A method was also developed for determining the diethyl ether soluble organic matter in U concentrates(XVI). A moving plate technique was applied to

the study of B volatilization from  $\text{Al}_2\text{O}_3$  oxide matrices during d-c arc excitation for spectrographic analysis (XV). (auth)

**16688 MCW-1398**

Mallinckrodt Chemical Works, St. Louis.

PROCESS DEVELOPMENT QUARTERLY REPORT.

PART II. Nona Kuhlman, ed. Nov. 1, 1956. Decl. Mar. 31, 1960. 144p. Contract W-14-108-eng-8. OTS.

The work of the pilot plants was directed toward the operation of the extraction cycle for the Weldon Spring refinery, removal of H from U metal, slag liner development, studies on the dingot process, fuel element studies, and processing of special  $\text{UO}_3$ . (W.L.H.)

**16689 MCW-1412**

Mallinckrodt Chemical Works, St. Louis.

PROCESS DEVELOPMENT QUARTERLY REPORT. PART

I. LABORATORY WORK. Barbara Elliott, ed. Apr. 1, 1958. Decl. Mar. 31, 1960. 164p. Contract W-14-108-eng-8. OTS.

Twenty-one lots of Vitro concentrate were found to contain an average of 4.7% of uranium that was insoluble in nitric acid. Individual lots ranged between 0.86 to 13.4%. The amount of insoluble uranium in Vitro concentrate was found to depend on the calcination temperature at the mill site. Fixation occurred chiefly in the temperature range 500 to  $800^\circ\text{C}$ . Use of a hydrogen atmosphere during calcination reduced the insoluble uranium content considerably. Climax, Rifle, Uravan, and Uranium Reduction concentrates contained less insoluble uranium than the Vitro product but still averaged over 0.2% insoluble uranium. Freezing point and boiling point data on uranyl nitrate solutions in the concentration range  $\text{UO}_2(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$  to  $\text{UO}_2(\text{NO}_3)_2 \cdot 1\text{H}_2\text{O}$ (32.4 to 54.9% uranium) are reported. Viscosity and surface tension measurements were made on a few solutions in this composition range. Degradation products of the plant solvent were found to inhibit uranium stripping. This inhibition is due to the formation of difficultly extractable complexes and also to an aggravation of solvent entrainment problems. These degradation products are probably the result of nitration reactions. The feasibility of recovering nitrate values from the Weldon Spring raffinate by additional TBP-hexane extraction stages has been demonstrated on a laboratory scale. The process utilizes sulfuric acid to displace fixed nitrate into the solvent. In contrast to distillation methods of recovering this nitrate, little chloride contamination of the recovered acid occurs. Ammonium sulfate, when added to the plant denitration pots, was found to be as effective as  $\text{H}_2\text{SO}_4$  in increasing the reactivity of resultant  $\text{UO}_3$ . Uranyl sulfate seemed to be slightly less effective. A systematic study of the increase in reduction rate with the sulfate content of  $\text{UO}_3$  is reported. The relatively unreactive product from the fluid-bed denitration could be effectively activated by hydration prior to reduction. The reaction of hydrogen fluoride with uranium metal turnings does not easily go to completion at temperatures up to  $660^\circ\text{C}$ . If the metal is treated first with hydrogen, then complete conversion to  $\text{UF}_4$  can be obtained easily at 400 to  $650^\circ\text{C}$  (98.5% yield). Preliminary tests of the Fluorox reaction were made with moderate success. A review of the status of research on this reaction is given. Confirmation was obtained of the significantly faster uptake of hydrogen by liquid uranium from an  $\text{H}_2$  atmosphere than from an  $\text{H}_2\text{O}$  atmosphere. This difference in rate was found to be greater at higher gas pressures, at least up to 590 mm Hg. The rate difference is at least eight-fold at 590 mm Hg and may be considerably greater. A mechanism is proposed that correlates the uranyl fluoride content of green salt

with (a) the dependence of the hydrogen content of uranium on the firing time of the bomb, (b) the dependence of metal yield on firing time, and (c) the dependence of firing time on green salt composition. Experimental support for the mechanism is presented. The hydrogen content of uranium was decreased by using magnesium of lower surface area. This decrease was correlated with the hydrogen analysis of the magnesium. Crude bomb yields began to fall off when magnesium of surface area less than about 100 sq cm/g was used.  $ZnCO_3$ ,  $UO_3$  and  $UO_2CO_3$  additives to the bomb charge all reduced the hydrogen content of resulting metal. The  $ZnCO_3$  and  $UO_3$ , however, reduced the metal yield. In analytical development work, essentially quantitative recovery of TBP added to NOK and UNH solutions was achieved. Data and conditions for routine control testing of these samples are presented. A rapid and accurate method for the infrared determination of  $n$ -hexane in plant hexane is presented. It was demonstrated that the pyrohydrolytic method is superior to the titrimetric method for uranium assay of uranium tetrafluoride with respect to speed, accuracy, and precision. A suitable procedure for routine uranium assay of the tetrafluoride is described. A number of leaching procedures for the determination of uranyl fluoride in uranium tetrafluoride were tested and found unsuitable. The use of the polarographic method following total sample dissolution is recommended. (auth)

**16690** MCW-1415

Mallinckrodt Chemical Works, St. Louis.

PROCESS DEVELOPMENT QUARTERLY REPORT.

PART I. LABORATORY WORK. John Nelson, ed. July 1, 1958. Decl. Mar. 31, 1960. 180p. Contract W-14-108-Eng-8. OTS.

Optimum temperatures were found to be in the range of 670 to 730°C for the carbon monoxide or hydrogen reduction treatment of Vitro concentrate to minimize nitric acid insoluble uranium. Little variation in insoluble uranium content was found with reduction retention times in the range 0.5 to 2 hours except in the case of exceptionally dilute reducing gases. A reducing gas flame was found to be a qualitatively satisfactory source of reducing gas. The fraction of the uranium in Vitro concentrate undissolved by nitric acid digestion was found to be influenced by digestion time, terminal acidity, and feed blends. Of these variables the digestion time appeared to be the most important variable affecting maximum uranium recovery. Distribution coefficient data suggest that the inclusion of the proposed nitric acid-solvent extraction process in the current refinery flowsheet would result in extraction of most of the thorium, in the absence of thorium-complexing agents. Kinetic data predict that the thorium profiles in the plant extraction system would require days or weeks to reach equilibrium. Thermal decomposition of the ammonium fluoride-uranyl fluoride double salt ( $3NH_4F \cdot UO_2F_2$ ) was found unsuitable as a method of preparing  $UF_4$ . Correlations between the firing duration of 4-kg laboratory dingot bombs with both the preignition time and the hydrogen content of the metal produced were found. "Domal" magnesium was found to have a significantly higher surface-to-volume ratio than either Reade or Metals Selling's magnesium, as well as a higher hydrogen content. This "Domal" magnesium produced metal in these dingots with a slightly higher hydrogen content than the other two magnesia. Preliminary experiments indicated that massive pieces of scrap uranium in quantities up to 7% of the weight of the charge could be remelted by addition to 4-kg reduction bombs with no apparent loss of metal yield. The wet process green salt product from a previously described scrap metal process was reduced in laboratory

bombs with yields only slightly less than with normal green salt. Excer process green salt made at ORNL could not be successfully reduced in the laboratory scale bomb as received. Grinding before reduction, however, did permit the production of metal of indifferent quality. Extension of the work done at Battelle showed the feasibility of recovering uranium in the form of scrap turnings by melting under a molten salt cover.  $LiF-CaF_2$ ,  $MgF_2-CaF_2$ , and  $LiF-MgF_2-CaF_2$  baths all gave good salt-metal separations, and satisfactory purity of the consolidated metal. Optimum conditions for removal of uranium from bomb slag by the fluoride volatility method in laboratory equipment were found to be: fluorination at about 400°C for a minimum of 30 minutes with bed depths of about  $\frac{1}{4}$  inch and fluorine flows at 0.85 l/min. Particle size of the slag must be reduced to less than 200 mesh for reasonable recovery efficiencies. Uranium metal could not be efficiently hydrofluorinated by the direct reaction with hydrogen fluoride. If the metal was first hydrided by reaction with hydrogen at 250°C, the product could then be converted to green salt by hydrofluorination. Further data are reported on the gas chromatography of commercial hexane. Two new column substrates are compared for separation efficiency, and analytical precision data are reported. The development and operation of apparatus for the determination of hydrogen in magnesium metal by low-temperature vacuum fusion are described. Uranium in slag has been determined by the x-ray spectrograph. The use of strontium as an internal standard and the sample preparation procedures are described. A method for estimation of the magnesium oxide and hydroxide content of slag and slag liner was developed. The slag is leached with excess standard sulfuric acid, and the excess is back-titrated with sodium hydroxide to determine the acid consumption. (auth)

**16691** MCW-1421

Mallinckrodt Chemical Works, St. Louis.

PROCESS DEVELOPMENT QUARTERLY REPORT.

PART II—PILOT PLANT WORK. Barbara Elliott, ed. Nov. 1, 1958. Decl. Mar. 31, 1960. 104p. Contract W-14-108-Eng-8. OTS.

The washing of solvent with dilute sulfuric acid followed by sodium carbonate solution was found effective in a pilot plant study of solvent treatment. Theoretical calculations indicate that the addition of phosphoric acid to the wash column will effectively improve thorium decontamination in the refinery. Pulse columns were used successfully in the pilot plant study of the recovery of nitric acid from raffinates by solvent extraction. Acid was recovered as a 12.5% solution with yields as high as 92%. A method was developed for using the pot wall temperature to control the denitration pot cycle. The denitration pots will be changed to this type of control. Extended pot life and better control of product uniformity is expected from this change. Seven runs were made in the new continuous pilot plant fluid-bed reactor.  $UO_3$  production rates of up to 200 lbs/hr/sq ft were achieved, and heat transfer coefficients of 30 to 70 Btu/hr/sq ft°F were observed. A continuous fluidized-bed hydrofluorination reactor was designed for pilot plant investigation of the usefulness of the varying cross-section technique in this step. The reactor was designed to process 75 pounds of  $UO_2$  per hour. Attempts to achieve low hydrogen contents in dingot metal by bomb reactions conducted in vacuum, through hydrogen-absorbing additives to the liner, or by protecting the molten metal of the bomb as much as possible from any contact with liner or product slag were ineffective. Adequate vacuum outgassing of 7-inch-diameter rounds of dingot uranium at 1850°F can be achieved within

reasonable pumping time periods. Direct casting from the dingot bomb shell in vacuum to a graphite mold is under study as a means of hydrogen removal. (auth)

**16692 MCW-1447**

Mallinckrodt Chemical Works. Uranium Div., Weldon Spring, Mo.

ELECTROREDUCTION OF URANIUM OXIDES TO MASSIVE URANIUM METAL. R. D. Piper and R. F. Leifield. Apr. 25, 1960. Changed from OFFICIAL USE ONLY June 3, 1960. 15p. Contract W-14-108-eng-8. OTS.

Production of massive uranium metal by fused salt electrolysis of uranium dioxide at temperatures above the melting point of uranium has been demonstrated on a laboratory scale. Oxide contamination of the product is avoided by the use of a consumable uranium oxide-carbon anode. This technique permits reduction of uranium oxide without direct introduction of it into the electrolyte. Massive pieces of metal up to 370 grams in weight have been produced at current efficiencies up to 39%, and metal quality has been very encouraging. Improvement in both current efficiency and metal quality are considered probable as the scale of operation is increased. (auth)

**16693 NBL-105**

New Brunswick Lab., AEC, N. J.

GREEN SALT MOVING BED PROCESS. R. W. LeGassie, E. S. Roszkowski, H. W. Bertram, and G. J. Petretic. June 1955. Decl. Mar. 31, 1960. 66p. OTS.

The production of  $UF_4$  pellets by processing  $UO_3$  feed in a moving-bed reactor was investigated. Specification-grade  $UO_2$  and  $UF_4$  pellets were produced in bench-scale moving-bed operations. Reaction rates for the thermal dissociation and  $H_2$  reduction of  $UO_3$  in the presence of  $N_2$  or steam were determined. Reaction rates for the hydrofluorination of  $UO_2$  in the presence of steam were also determined. (auth)

**16694 NLCO-720**

National Lead Co. of Ohio, Cincinnati.

CHEMICAL EQUILIBRIA AND REACTION RATES FOR HYDROFLUORINATION OF  $UO_2$  FROM "AMMONIUM DIURANATE" AND FROM  $UO_3$ . G. G. Briggs. Mar. 12, 1958. Decl. Mar. 28, 1960. 70p. Contract AT(30-1)-1156. OTS.

Reaction rates for the hydrofluorination of  $UO_2$  derived from two widely different source materials (sulfated pot-denitrated  $UO_3$  and "ammonium diuranate," (ADU) were determined in a thermobalance over a wide range of temperatures (460°F to 1150°F) and with several HF-H<sub>2</sub>O gas phase mixtures varying from 20 to 100 per cent HF. These data were then organized to yield single plots for each type of feed material. From these plots, maximum instantaneous reaction rates may be determined. These values may be applied to problems dealing with the estimation of minimum retention times required for hydrofluorination in counter-current gas-solid contactors. In addition to the rate studies, the thermobalance was used to establish temperatures corresponding to equilibrium in the system,  $UO_2(s)-UF_4(s)-HF(g)-H_2O(g)$ , at several selected HF/H<sub>2</sub>O ratios in the gas phase. These data, together with thermodynamic theory, were employed to calculate equilibrium conditions at total pressures other than one atmosphere and for various dilutions of the gas phase with an inert gas. (auth)

**16695 NLCO-760**

National Lead Co. of Ohio, Cincinnati.

SUMMARY TECHNICAL REPORT FOR THE PERIOD JULY 1, 1958 TO SEPTEMBER 30, 1958. John W. Sim-

mons, ed. Decl. Mar. 28, 1960. 115p. Contract AT(30-1)-1156. OTS.

Stanleigh, Stanrock, Milliken, Dyno, and Rayrock concentrates were approved as feed materials for the Refinery. Ohio Oil Lignite-Northgate Lignite (a combined feed) has not been approved. The coalescence time of tributyl phosphate-kerosene solvent was reduced temporarily by treatment with activated bauxite. A relationship was found between the flooding capacity of an extraction column and the coalescence time of the solvent used. Electronic absorption spectral studies demonstrated that a stable, equimolar complex was formed in the tributyl phosphate-nitric acid system between associated nitric acid ( $HNO_3$ ) and tributyl phosphate (TBP). The addition of 750 ppm sulfate to ammoniated uranyl nitrate prior to pot denitration increased the reduction rate of the product  $UO_3$ . The addition of 750 ppm phosphate to sulfated uranyl nitrate prior to pot denitration slightly decreased the activating effect of the sulfate. Preliminary results are presented from the continuous diffraction study of the reduction of  $UO_3$  to  $UO_2$ . The solids feed rate to a reduction reactor in the Green Salt Plant was controlled within  $\pm 2.5$  per cent by a feed-control system. The reaction between steam and green salt to produce HF and  $UO_2$  was demonstrated in the laboratory, utilizing thermobalance equipment. The reaction proceeds rapidly to completion at 1200°F and will yield aqueous HF containing at least 70 weight per cent HF at this temperature. A rectification column, seven feet high and one inch in ID was used to distill aqueous HF. The column was packed with  $1/8$ -in. irregular carbon particles and was designed without a reboiler or stripping section for a saturated vapor feed. When a vapor feed of 66 per cent HF was used and the still was operated at total reflux, the distillate approached anhydrous HF, while the bottoms averaged 47.6 per cent HF. A vapor feed of 18 per cent HF resulted in a distillate of approximately 0.5 per cent HF and a bottoms concentration of 28.6 per cent HF. The results of brief scoping tests in the laboratory indicate the feasibility of a scheme for the recovery of anhydrous HF from depleted  $UF_6$ , based upon the following over-all chemical reaction:  $UF_6 + H_2SO_4 + 2 H_2O \rightarrow UO_2SO_4 + 6HF$ . The particle size distribution, morphological characteristics, and occurrence of contaminating phases were studied in samples of three types of green salt: standard, high- $UO_2F_2$ , and high-AOI. In the pilot-scale semi-continuous reduction of uranium tetrafluoride to uranium metal, 6 per cent in excess of the stoichiometric amount of magnesium was found preferable to either 2 per cent or 4 per cent. A short-term reduction-pouring was demonstrated in a two-way tilt lip-pour induction furnace. Twenty-two reductions to uranium metal were performed in small-scale equipment, the average reduction conversion yield being 97.5 per cent. Tightly adhering slag was removed from 12-inch-diameter derbies by heating the derbies to 1300 to 1400°F and then quenching them in water. Graphite crucibles and graphite molds for the vacuum melting step were flame-sprayed with magnesium zirconate coating. The results of a statistically designed test indicated that there was no significant difference in the quality of the product produced at low and high pressure in a remelt furnace. The hydrogen pickup by uranium metal during heat treatment in 25 wt.%  $Li_2CO_3$ : 75 wt.%  $K_2CO_3$  salt and in 50 wt.%  $KCl$ : 50 wt.%  $NaCl$  salt was compared. A recording flame photometer was used to identify the spectra of nine elements in typical uranium concentrates. A rapid spectrophotometric method for the determination of nitrate in orange oxide is described. The range of the TTA-Thoron method was extended to include the determi-

nation of one to ten ppm thorium in uranium metal. (For preceding period see NLCO-750.) (W.L.H.)

**16696** NLCO-775

National Lead Co. of Ohio, Cincinnati.

SUMMARY TECHNICAL REPORT FOR THE PERIOD OCTOBER 1, 1958 TO DECEMBER 31, 1958. John W. Simmons, ed. Jan. 22, 1959. Decl. Apr. 28, 1960.

163p. Contract AT(30-1)-1156. OTS.

Refinery tolerance limits for rare earth elements were relaxed to 150 ppm each ( $U_3O_8$  basis) for gadolinium, dysprosium, samarium, and europium, eliminating the need for the 5N  $HNO_3$  extraction flow sheet in the Ore Refinery. Centrifugation is expected to substantially increase the efficiency of the treatment of used refinery solvent with aqueous sodium carbonate solutions prior to the recycle of the solvent. An activated bauxite treatment of a basic solvent was found effective in removing uranium, dibutyl phosphate, and carboxylic acids from the used solvent, but gives only a temporary improvement in coalescence. The time for uranium exchange between TBP and water was unaffected by the presence of sodium nitrate in the aqueous phase. Laboratory work showed that with increasing concentration of the  $TBP \cdot HNO_3$  complex in the organic phase, the distribution of uranium into TBP (the Refinery solvent) increases. The viscosity of aqueous raffinate (from the Refinery pulse-column operation) was studied in relation to the solids content of the raffinate, the boildown ratio of the raffinate, and acid recovery from the raffinate. The use of viscosity measurements to control the feed rate to the raffinate evaporator should prevent plugging of the evaporator heat-exchanger while providing satisfactory recovery of nitric acid. Molten uranyl nitrate was denitrated under "no-vacuum" conditions. Evaluation of the orange oxide produced indicated that denitration under these conditions does not significantly change the activity of the product from that produced by the normal (low-vacuum) method. A controlled-atmosphere high-temperature diffractometer hot stage is described. Samples of relatively unreactive lots of orange oxide ( $UO_3$ ) and reactive lots of orange oxide were analyzed, reduced to  $UO_2$ , and hydrofluorinated to  $UF_4$ . Sinterability of the  $UF_4$  was found to be related to the reactivity of the  $UO_3$ . In a test in which impurities (as fluorides) were added to  $UF_4$ , the additives promoted sintering in the following order: sodium (most sintering), iron, calcium, potassium, magnesium, nickel, thorium, and silica (least sintering). In the development of the ADU process, the use of aqueous  $NH_4OH$  solution containing 5%  $NH_3$  has made it unnecessary to add process chemicals to a vortex in the precipitator. ADU was produced at the rate of one ton per day. Calcination of ADU was found to increase surface area. Reduction of ADU to  $UO_2$  in a laboratory-scale fluid bed was studied. ADU was converted to green salt in the Green Salt Plant, and the green salt reduced to metal and cast as ingots in Pilot Plant Equipment. Results to date are very promising with respect to application of this process with a limited capital cost for continuous production of a very reactive and uniform Green Salt Plant feed. This development will replace the obsolescent batch denitration pots, with resultant process advantages to be expected throughout the metal production chain. Three size ranges of magnesium shot were compared with standard ground magnesium as reductant in the reduction of  $UF_4$  to derby metal. Yields were equivalent with medium-sized shot and were slightly lower with the fine and coarse-sized shot. In a pilot-scale evaluation of the reduction to metal step, addition of moisture to the slag liner of the reduction pot was found to improve derby yields and slag-metal separation with no

deleterious effects. Pilot-scale equipment for the semi-continuous reduction of uranium tetrafluoride was installed, tested, and found to have satisfactory efficiency and safety for reduction-pouring operations. Several short-time (3½-hour) demonstrations of the reduction-pouring operations were made. Hollow and solid slugs were cast by heating molten uranium to 2650°F, and pouring the metal into a heated mold rotating at 250 rpm. The use of glass sleeves and glass cores in the molds in which hollow slugs were cast gave slugs having little subsurface porosity. Carbide tools which contain large additions of tantalum carbide were found to be superior to other carbides tested for uranium machining. Hollow slugs that meet all specifications can be produced by precision drilling. A satisfactory production rate and tool life are obtained. It was recommended that the present six-operation method for fabricating hollow slugs be replaced by a four-step precision-drilling method. A beta heat treated structure in uranium metal was achieved by induction-heating 5-inch lengths of  $1\frac{1}{32}$ -inch and  $1\frac{1}{16}$ -inch-diameter rod. An "area weight" method for reducing the effects of a nonuniform spatial distribution of the poles of diffraction planes in preferred orientation studies is described. A portable battery-operated transistorized instrument for the detection of broken drill fragments in hollow uranium fuel elements was constructed. The instrument can reliably detect a fragment approximately  $\frac{3}{8}$  in. in diam. by  $\frac{1}{2}$  in. long if a fuel element containing the fragment is passed slowly through the probe. The sensitivity is appreciably increased by dropping the fuel element rapidly through the probe. A procedure was set up for exposing and processing color photomicrographs of uranium. Transparencies of good color quality can be made.  $UF_4$  was precipitated on a pilot scale from aqueous solution by the Winchester developed process. No problems were encountered that would indicate trouble in further scale-up; decontamination factors were high. The recovery of uranium from  $MgF_2$  scrap by hydrochloric acid leaching was studied on a laboratory scale. The corrosion and health hazards experienced when  $NaClO_3$  is used as an oxidant could be minimized by the substitution of  $MnO_2$  for  $NaClO_3$ . Yields of 38.7 to 81.1 per cent HF were achieved in laboratory-scale tests of the depleted  $UF_4 - H_2SO_4$  reaction. High-purity magnesium was produced by the reaction of  $MgF_2$  with  $CaC_2$  at 200 microns pressure in a laboratory test. In an investigation of the recovery of HF by treatment of  $MgF_2$  with  $H_2SO_4$ , the influence upon HF yield of (1) the temperature, (2) the per cent  $H_2SO_4$  in excess of the stoichiometric amount, and (3) the particle size of the  $MgF_2$  slag was determined. An x-ray-spectrographic method for the determination of uranium in  $MgF_2$  liner material is presented. The concentration range covered is 0.5 to 10 per cent uranium. The limit of error for an individual routine reporting value is 0.06 per cent uranium at the 95 per cent confidence level. A direct flame photometric method for determining calcium in uranium ore concentrates was found satisfactory. (For preceding period see NLCO-760.) (auth)

**16697** NYO-1355

Mallinckrodt Chemical Works, St. Louis.

PROCESS DEVELOPMENT QUARTERLY REPORT.

PART I. A. E. Ruehle and J. U. Shepardson, et al.

July 15, 1953. Decl. Apr. 21, 1960. 54p. Contract

W-14-108-eng-8. OTS.

Progress is presented on studies of the Waxco process, new raw materials, high  $(NH_4)_2C_2O_4$  insoluble in MCW  $UF_4$ , recovery of HF and U from  $MgF_2$  bomb slag, study of U metal with respect to metal quality, C contamination in cast U, vacuum fusion O determination, pyroelectric con-

centration methods for improving B sensitivity, grinding sample preparations for spectrographic analysis, and determination of N in U metal. (For preceding report see NYO-1353). (M.C.G.)

**16698** NYO-1363

Mallinckrodt Chemical Works, St. Louis.

PROCESS DEVELOPMENT QUARTERLY REPORT, PART II. May 1, 1954. Decl. Mar. 7, 1960. 197p. Contract W-14-108-Eng-8. OTS.

Progress is reported on the following investigations: ethyl ether extraction of aqueous  $UO_2(NO_3)_2$  solutions using a 4-in. jet mixer column, dissolution of U metal, U recovery from  $MgF_2$  slag residues, investigation of reduction bomb construction,  $MgF_2$  slug liner development, investigation of crucibles for U melting, development of improved production molds for U casting, ceramics for U casting, formation of U alloys by co-reduction, cutting U metal with an abrasive cutoff wheel, U metal dissolver operation, use of a side-entering agitator in the plant extraction column, processing of demilled  $UO_3$  through slug production, effects of green salt  $O_2$  content on slug yields, effect of pickled derbies on slug yields, and production of large derbies and ingots. (For preceding period see NYO-1360.) (B.O.G.)

**16699** NYO-5251

Mallinckrodt Chemical Works, St. Louis.

INHIBITION OF AIR OXIDATION OF  $UO_2$  BY HEAT TREATMENT. J. W. Stevenson. Mar. 21, 1952. Decl. Mar. 7, 1960. 12p. OTS.

The rate of oxidation of  $UO_2$  in storage varies from a high rate with  $UO_2$  produced at 620°C through intermediate rates for  $UO_2$  produced at 620°C then heat treated at 815°C to low rates for  $UO_2$  produced at 815°C. Temperature of heat treatment is more important than time, i.e., at 815°C 2 hrs are no more effective than 15 min but 900°C appears to give a lower rate of oxidation than 815°C. (B.O.G.)

## Separation Processes

**16700** CF-60-3-136

Oak Ridge National Lab., Tenn.

CHEMICAL TECHNOLOGY DIVISION, CHEMICAL DEVELOPMENT SECTION C PROGRESS REPORT FOR FEBRUARY-MARCH 1960. K. B. Brown. Apr. 27, 1960. 45p. OTS.

In recovering Mo from Amex nitrate strip solutions by adsorption on activated carbon, no significant loss of Mo adsorption power was observed in five cycles of adsorption and elution. Using synthetic carbonate leach liquors, a flowsheet for recovering U by extraction with a quaternary ammonium compound in kerosene-tridecanol and precipitation of U from the solvent with sodium carbonate-sodium hydroxide solution was tested in continuous equipment. The recovery of technetium and neptunium from fluorination plant residues is reported. Recovery of fission product strontium from synthetic Purex 1-WW was continued. The extraction of Th by di-n-decylamine sulfate was examined as a function of aqueous sulfuric acid activity at constant aqueous sulfate ion concentration. (For preceding period see CF-60-1-119.) (W.L.H.)

**16701** CF-60-6-4

Oak Ridge National Lab., Tenn.

EUROCHEMIC ASSISTANCE PROGRAM: TABULATION OF HAPO-BLUE PRINT FILE NUMBERS. E. M. Shank. June 2, 1960. 37p. OTS.

The Blue Print File groups provided by HAPO for Eurochemic were attached to cover pages, which listed

the BPF number and the information contained. These cover pages were combined and an ORNL-CF number assigned. (M.C.G.)

**16702** DP-275

Du Pont de Nemours (E. I.) & Co. Savannah River Lab., Aiken, S. C.

DISTRIBUTION OF URANYL NITRATE BETWEEN  $Al(NO_3)_3$  AND TRIBUTYL PHOSPHATE. Donald P. Ames and David G. Karraker. Mar. 1958. Decl. Mar. 28, 1960. 16p. Contract AT(07-2)-1. OTS.

The distribution of uranyl nitrate was measured from aluminum nitrate and nitric acid solutions into diluted tri-n-butyl phosphate. This information is useful for designing solvent extraction processes for recovery of uranium from aluminum nitrate or nitric acid solutions. (auth)

**16703** DP-296

Du Pont de Nemours (E.I.) & Co. Savannah River Lab., Aiken, S. C.

SCAVENGING OF RUTHENIUM FROM PUREX URANYL NITRATE SOLUTION. Charles A. Prohaska. June 1958. Decl. Mar. 28, 1960. 12p. Contract AT(07-2)-1. OTS.

Ruthenium in uranyl nitrate solutions from the Purex Process was adsorbed by the solid residue that remains when the solutions are concentrated by evaporation after treatment with thiocarbanilide and thioacetamide. Other chemicals were tested and the results are summarized. (auth)

**16704** DP-364

Du Pont de Nemours (E. I.) & Co. Savannah River Lab., Aiken, S. C.

BEHAVIOR OF TECHNETIUM IN THE PUREX PROCESS. Thomas H. Siddall, III. Apr. 1959. Decl. Mar. 28, 1960. 13p. Contract AT(07-2)-1. OTS.

Predictions of the behavior of technetium in the Purex Process and details of the chemistry of technetium for Purex Process conditions are given. The fraction of total technetium that reached the  $UO_2$  was found to be very dependent on the acidity in the 1A- and 1D-banks. (auth)

**16705** ERI-2240-6-F

Michigan. Univ., Ann Arbor. Engineering Research Inst.

STUDY OF THE FEASIBILITY OF AQUEOUS RECOVERY OF SPENT FUELS. PART 6. PARTIAL MATERIAL BALANCE FOR AQUEOUS RECOVERY PLANT. J. G. Lewis and H. A. Ohlgren. June 1954. Decl. Apr. 21, 1960. 21p. (HAO-20). OTS.

Work done for Dow Chemical-Detroit Edison and Associates, Atomic Power Development Project at Request of Consumers Power Co. (Jackson County).

A study of the feasibility of the aqueous recovery of spent nuclear fuels is presented. A partial material balance is described for the aqueous recovery plant being studied. The plant will consist of separate processing facilities for core elements and blanket elements but will be interchangeable in the event one facility fails to function properly. Flowsheets of the proposed separations process are included. (J.R.D.)

**16706** HW-19959

Hanford Works, Richland, Wash.

THE HYDROLYSIS PRODUCTS OF TRIBUTYL PHOSPHATE AND THEIR EFFECT ON THE TRIBUTYL PHOSPHATE PROCESS FOR URANIUM RECOVERY. R. M. Wagner. Apr. 15, 1951. Decl. Apr. 21, 1960. 39p. Contract W-31-109-Eng-52. OTS.

A study was made of the stability of tributyl phosphate (TBP) to acids, bases, and  $UO_2(NO_3)_2$  solutions, and of the chemistry of its decomposition products. The effect of

such decomposition products on the extraction behavior of U and the possibility of removing them from TBP prior to recycling was investigated. The preparation of monobutyl phosphoric (MBP) and dibutyl phosphoric (DBP) acids is described. Chemical and physical properties of MBP, DBP, and TBP were determined, and the kinetics of their hydrolysis was studied. The efficiency of NaOH,  $H_3PO_4$ ,  $Na_2SO_4$ ,  $Na_2CO_3$ , and water for the separation of MBP and DBP from diluents was determined. The extraction behavior of nitrated samples of pure Amsco 149-92 Br solvent and RAX (TBP + Deobase or Amsco 125-90W) before and after NaOH- $Na_2CO_3$  treatment was measured under RC extraction column conditions. The extraction behavior of U(IV) between TBP-Amsco 125-90 W and water in the presence of DBP, and TBP photodecomposition in the presence of uranyl ions were studied. The solubility was determined for the DBP's of Th(IV), Ce(IV),  $Al^{3+}$ ,  $ZrO^{2+}$ , and U(VI) in water,  $3M$   $HNO_3$ , and  $CCl_4$ . X-ray-diffraction lines of uranyl acid phosphate; uranyl phosphate; U(IV), Th(IV), zirconyl, Ce(IV), Al, and uranyl DBP's; uranyl MBP and zirconyl nitrate are tabulated. (M.C.G.)

**16707** HW-27492

General Electric Co. Hanford [Atomic Products Operation], Richland, Wash.

INVESTIGATION OF EXPLOSIVE CHARACTERISTICS OF PUREX SOLVENT DECOMPOSITION PRODUCTS (RED OIL). Robert M. Wagner. Mar. 17, 1953. Decl. May 3, 1960. 8p. Contract W-31-109-Eng-52. OTS.

A rapid reaction of explosive violence was found to be obtainable from mixtures of "red oil" and uranium solutions only under conditions of incipient calcination (~150 to 160°C). Eight experiments under reflux conditions (for 6 to 8 hr duration) to simulate the Purex U concentrators and three additional reflux experiments simulating the Purex waste concentrators resulted in slow evolution of  $NO_2$  but no uncontrolled reaction of explosive violence. The residual solutions from the reflux studies, when combined and evaporated, showed rapid decomposition only as calcining conditions were approached. The violence of the decomposition appeared to be a function of the absolute amount of "red oil" present and a secondary function of the ratio of UNH to "red oil." It is concluded that from the nature of the design of the Purex plant, conditions necessary to obtain violent explosive reactions between "red oil" and U solutions are effectively minimized for Hanford operations. (auth)

**16708** HW-30148

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

AN AUTOMATIC POLAROGRAPH FOR THE DETERMINATION OF URANIUM IN PROCESS WASTE STREAMS. K. Koyama, C. E. Michelson, and G. J. Alkire. Dec. 10, 1953. Decl. Feb. 10, 1960. 26p. Contract W-31-109-Eng-52. OTS.

A prototype of the automatic polarograph, as installed in the Metal Recovery Process, satisfactorily recorded the uranium concentration in the waste stream (RAW) every 10 minutes. Any operational adjustments of the Metal Recovery Process, which changed the uranium concentration of the RAW, were noted immediately by the polarograph. Consequently, a much closer control of the process was possible. In addition to the possible gain in efficiency of uranium recovery by reducing the amount lost to waste, a reduction of the sample load to the control laboratory resulted. Examples of improved process control were found in actual experience in cases in which feed concentrations increased until waste losses became excessive. This was immediately detected by

the RAW analyzer and a subsequent reduction of feed flow rate in each case resulted in immediate reduction in losses, as evidenced by the polarographic results. In many such instances, several hours of operation at high waste losses were avoided. A dropping mercury electrode was used for stream analysis, and the RAW solution was analyzed directly without either dilution or addition of supporting electrolyte. Removal of dissolved oxygen and control of temperature were unnecessary. The precision of the method was better than  $\pm 5\%$ , and the accuracy, which is dependent on calibration with a standard solution, was well within the precision value. The calibration curve is linear, for practical purposes, up to approximately 8 g/l UNH or 0.032 lb/gal uranium. (auth)

**16709** HW-32316

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

PILOT-PLANT STUDIES OF MERCURY-CATALYZED DISSOLVING OF ALUMINUM-JACKETED FUEL ELEMENTS. J. L. Bradford and K. L. Adler. July 1, 1954. Decl. Mar. 28, 1960. 22p. OTS.

Two-cut, mercury-catalyzed dissolving of Al-jacketed uranium fuel elements was demonstrated as feasible and readily controlled. Because results indicated a potential explosion hazard due to hydrogen and oxygen concentrations in the dissolver off-gas, the procedure was not considered ready for a Redox Plant trial. Complete removal of the aluminum was not achieved with catalyst,  $Hg(NO_3)_2 \cdot H_2O$ , concentrations of 2% or less. The shortest time cycle, 18 hours, was achieved when nearly all the aluminum was dissolved in the first cut. The second cut was then made with 60%  $HNO_3$ . An acid efficiency of about 80% for the first and 65% for the second cut was achieved in the catalytic dissolving cycle employing a downdraft condenser. (M.C.G.)

**16710** HW-37121

[General Electric Co. Hanford Atomic Products Operation, Richland, Wash.]

OPERATING LIVES OF REDOX MECHANICAL EQUIPMENT. R. L. Stevenson. Apr. 2, 1955. Decl. Mar. 28, 1960. 16p. OTS.

The operating lives of Redox Process mechanical equipment are given. Tables are included which give the operating hours, reason for failure, position, and original date installed. (W.L.H.)

**16711** HW-38667

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

A NEW APPROACH TO CONCATENATION OF PULSED COLUMNS. J. Oliver Ludlow. Aug. 16, 1955. Decl. Mar. 28, 1960. 7p. OTS.

A method of performing a series of solvent extractions using a minimum of pulse generators is briefly outlined. (J.R.D.)

**16712** HW-40313

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

AN ANALYSIS OF THE IN-LINE URANIUM PHOTOMETER DATA FROM PUREX HOT SEMI-WORKS, RUNS PX-2 THROUGH PX-9. F. A. Scott. Dec. 7, 1955. Decl. Mar. 28, 1960. 21p. OTS.

Results of eight runs using in-line U photometers in organic and aqueous streams of the Purex Hot Semi-Works are presented. Their operation, both mechanically and electrically, was satisfactory, indicating changes in stream U concentrations over wide ranges. (W.L.H.)

**16713 HW-48503**

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

PYROCHEMICAL SEPARATIONS PROCESSES OF POTENTIAL HAPO INTEREST. R. H. Moore. Feb. 18, 1957. Decl. Mar. 28, 1960. 21p. Contract [W-31-109-Eng-52]. OTS.

Two pyrochemical processes are considered and compared to present and proposed processes. A pyrochemical dissolution and head-end process using  $\text{BiBr}_3$  as solvent would possess all the advantages of other processes in addition to having lower operating temperature, less corrosion, and better reaction kinetics. A complete pyrochemical process producing decontaminated  $\text{UF}_6$  and partially decontaminated  $\text{Pu}(\text{NO}_3)_3$  would offer the additional advantages over other processes of compactness, simplicity, less criticality problem, smaller waste volumes, and equal or better economic aspects. (T.R.H.)

**16714 HW-49149**

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

GRADED PLATE CARTRIDGE FOR PUREX A-TYPE EXTRACTION COLUMN. R. G. Geier and G. M. Hesson. Mar. 20, 1957. Decl. June 10, 1960. 9p. OTS.

Graded nonuniform cartridges are described which have plates with larger holes, greater free area, and/or greater plate spacing. These plates were developed and specified for the Purex Plant A-type columns. Use of the cartridges eliminated cyclic local flooding and increased the complete flooding frequency by 10 and 25 cycles/min at volume velocities of 530 and 1060 gal/hr/sq ft, respectively, and exhibited satisfactory extraction efficiency over a wide range of frequencies and throughputs. (auth)

**16715 HW-51673**

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

THE IN-LINE ESTIMATION OF THE SULFAMATE ION CONCENTRATION IN THE PUREX IBP STREAM. F. A. Scott. Aug. 1, 1957. Decl. Mar. 28, 1960. 10p. Contract W-31-109-Eng-52. OTS.

A remotely operated and completely automatic sulfamate monitor capable of in-line application was constructed and laboratory tested. Plant application appears feasible although considerable design and development effort will be necessary before this is possible. The instrument uses the principle of dynamic titration with nitrite ion. It consists of two flow metering systems, a solution mixing system, a redox potential measuring cell, a recorder and a flow controlling system. The titrant to stream flow ratio necessary to attain a given redox potential is a measure of the amount of sulfamate in the stream. The laboratory prototype instrument will estimate the sulfamate ion concentration of a synthetic IBP stream over the range 0.01 to 0.04 molar with a precision of  $\pm 0.0005$  M. The accuracy is subject somewhat to the variables of stream temperature and nitric acid concentration. The effects of these and other variables were briefly studied and are discussed in this report. (auth)

**16716 HW-56477**

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

TECHNOLOGY OF NON-PRODUCTION REACTOR FUELS REPROCESSING—BUDGET ACTIVITY 2790. Quarterly Report. V. R. Cooper. June 19, 1958. Decl. Mar. 28, 1960. 7p. Contract W-31-109-Eng-52. OTS.

Sawing, shearing, and pulverizing of non-production fuel

elements to permit core leaching are being evaluated. The dissolution, for solvent extraction feed, of stainless steel clad elements in 5M  $\text{HNO}_3$ —2M HCl and  $\text{HNO}_3$ —HF, zirconium clad elements in aqueous ammonium fluoride, zircaloy-2 and -3 clad elements in  $\text{NH}_4\text{F}$ — $\text{H}_2\text{NO}_3$ , and uranium oxide elements in  $\text{HNO}_3$  is discussed. Feeds for the Purex and Redox Processes are considered. Corrosion tests on the materials for use in the aqua regia, HF— $\text{HNO}_3$ , and Zirflex systems were performed.  $K_{\text{e}}$  for several systems of enriched uranyl nitrate and water was determined. (For preceding period see HW-55419.) (W.D.M.)

**16717 HW-62086**

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

REPROCESSING OF LOW-ENRICHMENT URANIUM—MOLYBDENUM ALLOY FUELS. W. W. Schulz and E. M. Duke. Sept. 15, 1959. 37p. Contract AT(45-1)-1350. OTS.

Procedures for the dissolution of U-Mo alloy fuels to prepare feed solutions for low-acid (Redox) type solvent extraction processing are presented. U-Mo alloys can be dissolved in boiling ferric nitrate—nitric acid solutions to higher terminal uranium concentrations and lower terminal acidities without precipitation of uranyl molybdate than in nitric acid alone. Anion resin exchange studies indicate the presence of negatively charged iron-molybdenum complex ions in the solutions. The U-Mo alloys also dissolve more rapidly in ferric nitrate—nitric acid solutions than in nitric acid alone; dissolution rate data are given. Curves delineating free acid, uranium, and iron(III) concentrations within which solutions stable towards solids formation can be prepared from U-3 wt.% Mo and U-10 wt.% Mo alloys are presented. Stability during prolonged storage of uranium—molybdenum—ferric nitrate—nitric acid solutions is discussed. Data on the oxidation of plutonium in these solutions and on further neutralization of the solutions are presented. Fission product decontamination and product recovery obtained in solvent extraction studies simulating the Redox process are discussed. (auth)

**16718 HW-64416**

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

THE PILOT PLANT OPERATION OF A VERTICAL TUBE, RECIRCULATING DISSOLVER FOR THE DISSOLUTION OF URANIUM DIOXIDE IN NITRIC ACID. P. W. Smith. Mar. 21, 1960. 10p. Contract AT(45-1)-1350. OTS.

The results of a series of pilot plant dissolutions of  $\text{UO}_2$  in  $\text{HNO}_3$ , carried out in a vertical tube recirculating dissolver, are presented. Dissolution rates under recirculating conditions were essentially the same as rates predicted from batch data. (C.J.G.)

**16719 HW-65267**

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

TECHNOLOGY OF NON-PRODUCTION REACTOR FUELS REPROCESSING BUDGET ACTIVITY 2790 QUARTERLY REPORT. V. R. Cooper. May 19, 1960. 18p. OTS.

Current planning calls for location of the receiving and storage, mechanical treatment, dissolution, clarification, and solution storage facilities at the Uranium Recovery Plant. Hacksaw testing was completed with final tests on the last three types of saws. Scouting studies of the Yankee fuel disassembly were made. A 304-L stainless steel shear blade faced with Stellite was tested. A cluster of 15, Zircaloy-clad, swaged  $\text{UO}_2$  rods was sheared to study the dispersion of  $\text{UO}_2$  fines in basin fluid. The Zirflex Process, which employs aqueous  $\text{NH}_4\text{F}$  for dejacketing Zr-clad

elements was studied to determine the solubility of both Zr and U(IV). In the Sulfox Process for decladding stainless steel clad fuel elements, the compatibility of a soluble neutral poison, such as boron, with the decladding solution was studied. Also studied were dissolution of U-Mo alloy fuels,  $UO_2$  dissolution rates under recirculating conditions, effects of the recirculation rate on the dissolution rate of Al in  $Hg(NO_3)_2$ - $HNO_3$  solutions, and Redox extraction of U-Mo alloy fuels. Corrosion tests were made on experimental Ni-Cr-Fe-Mo alloys. The density of U and the atomic ratio of  $H_2$  to U were determined for  $UO_2$ - $H_2O$  mixtures. The maximum buckling and minimum critical mass for 3.06% enriched U rods were determined for various rod diameters. Nuclear safety reviews were made on the design of a process cell and a dissolver for handling 5% enriched U metal and  $UO_2$  fuels. (M.C.G.)

## 16720 IDO-14361

Phillips Petroleum Co. Atomic Energy Div., Idaho Falls, Idaho.

THE COMPOSITION OF OFF-GAS FROM BATCH URANIUM-ALUMINUM DISSOLUTION. M. D. Martin and J. A. Buckham. Dec. 15, 1955. Decl. Mar. 28, 1960. 31p. Contract AT(10-1)-205. OTS.

Full scale pilot-plant studies of the  $Hg$ -catalyzed  $HNO_3$  dissolution of unirradiated 7.5 wt.% U-92.5 wt.% Al alloy slugs were carried out in a batch dissolver. Nitrogen dioxide concentration in the dissolver is high during the early part of dissolution but decreases to a low value as the dissolver solution becomes neutral or acid deficient. Virtually all of the  $NO_2$  is absorbed in the condensate at the condenser. The  $H_2$  content is nearly constant for acidic dissolver solutions, averaging about 4% for extruded slugs and 2% for cast slugs. In extruded slug dissolution, the  $H_2$  in the off-gas increases rapidly to about 23% when the dissolver solution becomes acid-deficient. This  $H_2$  increase is accompanied by a decrease in NO. The data and correlations developed in these studies will permit the determination of the off-gas explosive hazards which may exist under various conditions of dissolution. (auth)

## 16721 IDO-14391

Phillips Petroleum Co. Atomic Energy Div., Idaho Falls, Idaho.

IDAHO CHEMICAL PROCESSING PLANT TECHNICAL PROGRESS REPORT FOR APRIL THROUGH JUNE 1956. C. E. Stevenson. Jan. 15, [1957]. Decl. Mar. 28, 1960. 54p. Contract AT(10-1)-205. OTS.

Plant operating experience is summarized and evaluation of plant processes and assistance to plant processes is reported. Development studies in analytical methods, process analytical instrumentation, process equipment and equipment testing are continued. Research is reported in preparation and dissolution of long tubular fuel elements,  $Al(NO_3)_3$  waste calcination studies, and Cs recovery by  $Fe(CN)_6^{4-}$  scavenging. (T.R.H.)

## 16722 IDO-14422

Phillips Petroleum Co. Atomic Energy Div., Idaho Falls, Idaho.

IDAHO CHEMICAL PROCESSING PLANT TECHNICAL PROGRESS REPORT FOR JULY THROUGH SEPTEMBER 1957. C. E. Stevenson. Dec. 31, 1957. Decl. May 4, 1960. 148p. Contract AT(10-1)-205. OTS.

A flowsheet was developed and plant-tested (Cold) to permit return of second and third cycle scrub waste as first cycle TBP process scrub. Laboratory studies of oxalic and phosphoric acid employed to direct Pu and Zr to first cycle waste are reported. The removal of iodine from  $Ba^{140}$

process off-gas by charcoal was studied, and an adsorption system devised. The corrosion of stainless steel, Monel, titanium, and tantalum by boiling decontaminating reagents was studied. The study of the effect of geometrical shape on the dissolution rate of 2-S Al in  $Hg$ -catalyzed 5.6M  $HNO_3$  at 80 to 100°C was completed. Studies of pulse column pressure transients were carried out to develop the causes of such transients observed in plant equipment. Pilot plant tests were made to determine if holding extraction column feed for periods of days prior to extraction adversely affects U recovery. The effectiveness of static pressure probes to indicate column flooding was evaluated. The development of an instrument to detect abnormal U concentrations in extraction raffinate streams is described. Service tests of modified canned rotor pumps were continued. A thermal flowmeter was tested, and a pulse amplitude indicator devised. The kinetics of Zr dissolution are being studied in mixtures of  $HNO_3$  and HF. The ion exchange, solvent extraction, and precipitation of Zr from various media are described. Problems encountered in the operation of a small waste calciner for production of experimental quantities of high-activity calcined solids are described. Studies of Ru behavior in calcining included an evaluation of the effect of a nitric oxide atmosphere in suppressing volatility, distribution of Ru in the pilot plant off-gas system, adsorbents for Ru, and mercaptide precipitation. The effectiveness of a venturi scrubber for particle removal was also studied. Corrosion of heating surfaces and spray nozzles is reported, and data are given for the leaching of fission products from calcined alumina. Data for the B content of ingots used in ETR fuel element production were used to estimate the amount of B in selected elements. Statistical studies were made of the carminic acid method for B determination, the isotopic dilution method for U analysis, TBP determination by acid extraction, and experimental techniques for waste calcination and Zr extraction. Improvements in spectrophotometric methods for the determination of U were developed. (W.L.H.)

## 16723 IDO-14494

Phillips Petroleum Co. Atomic Energy Div., Idaho Falls, Idaho.

IDAHO CHEMICAL PROCESSING PLANT TECHNICAL PROGRESS REPORT FOR APRIL THROUGH JUNE 1959. C. E. Stevenson. Mar. 22, 1960. 73p. Contract AT(10-1)-205. OTS.

Inspection of a Type 347 stainless steel evaporator tube bundle, after eleven months of plant service in concentrating aluminum nitrate, revealed grain boundary and end grain attack which would greatly limit its useful life. This bundle was replaced with one constructed of titanium. Test coupons removed from tanks in which high activity wastes were stored indicated essentially no corrosion after four years in aluminum nitrate waste, and less than 0.2 mils per year corrosion after 2.5 years in zirconium process waste solution. Dilute nitric acid containing mercuric and mercurous nitrates was found to be a useful scrubbing agent for removing iodine from barium-140 process off-gas. In studies of process methods for aluminum fuel recovery, the addition of gelatin was found to reduce emulsion formation significantly in laboratory tests with silicon-bearing TBP process feed solutions. Dilute hydrofluoric acid and sodium tartrate solution appeared to be more effective than sodium carbonate in reducing the gamma activity of hydrocarbon diluent used to wash uranium product solution. Studies of processing in the acid-deficient region indicated that mercury precipitation and uranium occlusion might limit satisfactory operation to an inter-

mediately basic composition and only moderately greater aluminum concentration than is possible under acid conditions. It was determined that small amounts of hydrogen peroxide, chromic acid, or permanganate could be used with hydrofluoric acid to produce homogeneous solutions from alloys containing 2 to 3 percent uranium in zirconium. Lowest corrosion of Monel occurred with peroxide. Zirconium was dissolved electrolytically in methanol containing hydrogen chloride. In dissolving irradiated Zircaloy-uranium alloy in molten lead chloride, cesium and cerium were found primarily in the salt phase, while ruthenium accompanied metallic lead. When zirconium was precipitated as barium fluozirconate from ammonium fluoride dissolutions, carrying of uranium was minimized by complexing with chloride or oxalate. Alumina ceramic structures were found to lose mechanical strength when exposed to 8M hydrofluoric acid containing 1M nitric acid. Stainless steel fuel elements used in the Organic Moderated Reactor Experiment acquired an organic film which resisted attack by sulfuric acid. Studies of reagents which would remove this film indicated that an oxidizing material normally used for vessel decontamination would accomplish film removal simply and satisfactorily. In other studies of stainless steel fuel processing, it was shown the iron salts markedly reduced the volatility of chloride from nitrate solutions. Electrodeposition of metal ions into a mercury cathode from sulfate solutions of stainless steel in the presence of cesium, strontium, and cerium was accomplished with decontamination factors of 400 to 20,000. Polarographic studies indicated the mechanism for chromium reduction in this process. Excellent performance was obtained from canned rotor pumps with special bearings. A valveless pump and a bellows pulser which are driven by air were preliminarily tested. In development of the fluid bed waste calcination process, a silica gel column was loaded with almost 60 grams of ruthenium per cubic foot of gel while maintaining high off-gas decontamination. Operation of the NaK-heated pilot plant calciner was continued. In tests of venturi scrubbing of particles from the off-gas, it was noted that high scrubbing efficiency accompanied high pressure drop across the scrubber. Up to 99% of sub-micron particles were removed by an electrostatic precipitator operating at 10 kilovolts. Tests of mechanical performance of a silica gel absorber bed indicated little decrepitation in a water-saturated bed. The bed effectively acted as a filter for removal of dust particles. A study of the heat liberation rate of waste stored in a 300,000 gallon tank was made. Modified methods were developed for the determination of the acidity and uranium content of zirconium process solutions. A rapid colorimetric method was devised for determining uranium in sulfuric acid process solutions. Improvements were made in a method for the estimation of neptunium in process solutions. (For preceding period see IDO-14471.) (W.L.H.)

**16724 KAPL-795(Pt.III)**

Knolls Atomic Power Lab., Schenectady, N. Y.  
AN INVESTIGATION OF THE  $\text{KMnO}_4$ — $\text{MnO}_2$  HEAD-END PROCEDURE FOR THE REMOVAL OF RUTHENIUM AND NIOBIUM—ZIRCONIUM. III. A LARGE-SCALE STUDY WITH NONIRRADIATED URANIUM IN THE SEPARATIONS PILOT PLANT. J. F. LaBonte and E. F. Palmer. Mar. 5, 1953. Decl. Apr. 21, 1960. 35p. Contract W-31-109-Eng-52. OTS.

A study of the  $\text{KMnO}_4$ — $\text{MnO}_2$  head-end procedure for the removal of Ru, Nb, and Zr was conducted. The scope of the

investigation was outlined in KAPL-795. A large-scale investigation in which natural-U solutions were centrifuged in a 26-in.-diam. Bird centrifuge is described. In this study, their effects on the efficiency of centrifugation, variables such as acidity, feed temperature, method of feeding, U molarity, strike agent, cake volume, cake removal, baffle design, feed age, and  $\text{MnO}_2$  concentration were studied. (auth)

**16725 KAPL-1543**

Knolls Atomic Power Lab., Schenectady, N. Y.  
A LOW WASTE VOLUME, FIRST CYCLE, 1A PUREX FLOW SHEET. J. K. Davidson and W. O. Haas, Jr. July 15, 1956. Decl. May 18, 1960. 71p. Contract W-31-109-Eng-52. OTS.

The KAPL No. 6, first-cycle Purex 1A flow sheet is presented as an example of waste volume reduction through optimum solvent-extraction flow sheet design. Calculated on the basis of previous flow sheets, a 54 to 69% reduction of first-cycle waste storage volume is achieved by taking advantage of the extractability and reflux of nitric acid in TBP systems to provide adequate salting while minimizing the amount of acid going to waste. Although this report is concerned only with the first Purex cycle, the calculations are equally valid for the second U cycle, and the principles presented are applicable to similar nitric acid-salting TBP systems. (auth)

**16726 MCW-1395**

Mallinckrodt Chemical Works, St. Louis.  
SLAG PROCESSING AND MAGNESIUM FLUORIDE SOLUBILITY. J. W. Varwig and G. L. Martin. Mar. 1, 1957. Decl. Mar. 31, 1960. 36p. Contract W-14-108-Eng-8. OTS.

The U-Con product of the Slag Residue Plant can be satisfactorily processed at the SLP. U-Con digestion presents no difficulty provided the material is added slowly, with strong agitation, to avoid a buildup of unreacted material. Aluminum can be safely added to complex the fluoride without significantly increasing the soluble fluoride concentration. Extraction of U with ether is favored if Al is present in the feed liquor. The presence of Al helps to reduce both the loss of U to the raffinate and the contamination of the extract with fluoride. Uranium and Al both increase the rate of solution and solubility of  $\text{MgF}_2$ , probably because of complex fluoride formation. The appearance of the  $\text{MgAl}$  fluoride was unexpected. However, it did not form when fused  $\text{MgF}_2$  was used and its equilibrium fluoride concentration in synthetic digest solutions was intolerably high. The solubility (10 g F/l) of the U-Con tailings in the synthetic digest solution is also too great to be tolerable. The results which were obtained with U-Con tailings indicate that the quantity of  $\text{MgF}_2$  in a digestion system must be carefully controlled or excessive fluoride levels may be encountered. Unless specific information is available to the contrary, this is the only practical way to prevent serious fluoride problems. Adequate control at levels below 5 g F/l can be obtained by using Al. Why the various  $\text{MgF}_2$  exhibit such different solution rates is not known. Particle and/or crystallite size is suspected, but the exact role of each and the existence of other influential factors was not established in this work. (auth)

**16727 NLCO-714**

National Lead Co. of Ohio, Cincinnati.  
STUDIES OF THE BEHAVIOR OF THE TBP-KEROSENE SOLVENT IN URANIUM REFINING: RECOVERY OF DISCARDED REFINERY SOLVENT. Robert H. Ellerhorst. Jan. 17, 1958. Decl. Apr. 28, 1960. 25p. Contract AT(30-1)-1156. OTS.

A series of laboratory tests showed that uranium is retained in the tributyl phosphate-kerosene solvent extraction stream during re-extraction as a result of the formation of non-water-strippable uranium complexes and the decrease of uranium mass transfer rate at the re-extraction stage. The uranium retained by complexing is held by dibutyl phosphate (DBP) and other unknown complexing agents. Continuous solvent treatment, using a 3-step cycle of sodium carbonate-water-nitric acid, removes the DBP and the agent(s) affecting the decrease of mass transfer rate and slowly reduces the concentration of the unknown uranium-complexing agents. (auth)

## 16728 ORNL-1792

Oak Ridge National Lab., Tenn.

A COST ANALYSIS OF THE IDAHO CHEMICAL PROCESSING PLANT. P. L. Robertson and W. G. Stockdale.

Jan. 4, 1955. Decl. June 5, 1959. 160p. OTS.

A capital cost breakdown of the Idaho Chemical Processing Plant, a directly maintained remotely operated plant for processing spent enriched uranium fuel assemblies from reactors, is presented. The capital investment in the plant, including design, construction, training, and preoperational costs, an estimate of the direct costs incurred by the Atomic Energy Commission, and a proportional part of the costs of Central Facilities, including the value of the land and improvements thereon when acquired by the Commission, was \$31,105,899. The cost of design and construction was \$25,212,231, of which \$3,773,357 was expended on design and inspection. (auth)

## 16729

RADIOMETRIC EXTRACTION METHOD FOR FLUORIDE. PYROLYSIS-ION EXCHANGE SEPARATION. William J. Maeck, Glenn L. Booman, Maxine C. Elliott, and James E. Rein (Phillips Petroleum Co., Idaho Falls, Idaho). Anal. Chem. 32, 922-5(1960) July.

In many liquid-liquid extraction systems, complexing anions cause lowered extraction of metal ions. The potentiality of using this as the basis for determining anions has been investigated with the system hafnium-fluoride-triethylphosphine oxide. An inverse linear response was obtained for hafnium extraction vs. fluoride concentration for 2 to 10  $\mu$ moles of fluoride. Hafnium distribution is rapidly determined using  $Hf^{181}$  tracer and gamma counting the liquid phases. Pretreatments by pyrolysis to separate fluoride from metal ions and anion exchange to separate it from interfering anions are described. At the 250- $\mu$ mole fluoride level in the original sample, the coefficient of variation for the over-all procedure, including pyrolysis, ion exchange, and extraction, is 3.3%. (auth)

## 16730

ION EXCHANGE SEPARATION OF METAL CATIONS.

James S. Fritz and Shirley K. Karraker (Ames Lab., Ames, Iowa). Anal. Chem. 32, 957-60(1960) July.

Metal cations can be conveniently separated into groups by elution of a cation exchange column with an ethylenediammonium perchlorate solution. Most divalent ions are eluted from the column with 0.1M eluent. Then trivalent metal ions (plus Ba and Pb) are eluted with 0.5M ethylenediammonium perchlorate. Bismuth, thorium, and zirconium remain quantitatively on the column after this treatment. The effect of temperature and of certain complexing anions on the separations was studied. (auth)

## 16731

LIQUID-LIQUID EXTRACTION OF POLONIUM-208 TRACER FROM BISMUTH TARGET SOLUTIONS. Fletcher

L. Moore (Oak Ridge National Lab., Tenn.). Anal. Chem. 32, 1048-9(1960) July.

Polonium-208 is produced in the cyclotron irradiation of bismuth targets. It has been found that ~90% of the  $Po^{208}$  tracer could be carried on lanthanum fluoride from 1M nitric acid solution. A method is described in which the extraction is made from a hydrochloric acid solution with diisopropyl or diisobutyl carbinol. The procedure is rapid, readily adaptable to remote control, and provides yields of greater than 98%. (B.O.G.)

## 16732

THE USE OF ION EXCHANGE RESINS FOR EXTRACTION OF RADIOACTIVE FISSION PRODUCTS FROM PRECIPITATIONS. Dieter Dunkel (Universität, Munich). Atomkernenergie 5, 183-7(1960) May. (In German)

Radioactive substances in atmospheric fall-out are detected more successfully by means of ionic-exchange than with the boiling method. Systematic investigations resulted in the fact, that most of the solute radioactive ions are alkaline earths. Rare earths and heavy metals contribute only some percent to the solute activity. With this fact special forms of decay-curves are quantitatively described. (auth)

## 16733

ON THE MECHANISM OF THE EXTRACTION OF URANYL NITRATE BY TBP (PARTITION STUDY). Keiji Naito (Japan Atomic Energy Research Inst., Tokyo). Bull. Chem. Soc. Japan 33, 363-71(1960) Mar. (In English)

A method of analysis using the distribution coefficient to confirm the mechanism of extraction is proposed and the formation of the complex  $UO_2(NO_3)_2 \cdot (TBP)_2$  and  $HNO_3 \cdot TBP$  was confirmed. The extraction behavior of uranium from a nitric acid solution was concluded as a result of the competition of uranium and nitric acid. The thermochemical functions  $\Delta H^\circ$ ,  $\Delta F^\circ$ , and  $\Delta S^\circ$  for the complex formation reaction,  $UO_2^{2+}(aq) + 2NO_3^-(aq) + 2TBP(org) = UO_2(NO_3)_2(TBP)_2(org)$ , were determined at 25°C roughly from the distribution coefficient as follows:  $\Delta H^\circ \approx -4.3$  kcal,  $\Delta F^\circ \approx -2.0$  kcal,  $\Delta S^\circ \approx -7.7$  e.u. (auth)

## 16734

QUESTIONS ON REACTOR FUEL ELEMENT PROCESSING. Stefan Krawczynski (Kernreaktor Bau- und Betriebs-Gesellschaft m.b.H., Karlsruhe, Ger.). Kerntechnik 2, 157-60(1960) May. (In German)

The problems and the necessity of fuel element processing are described by means of a simple example. Since economic processing was destroyed by the multiplicity of existing fuel elements, the requirements are increased with respect to a broad fuel element program. (tr-auth)

## 16735

REPROCESSING FUEL FROM THE CIVIL REACTORS. K. Saddington (United Kingdom Atomic Energy Authority, Sellafield, Eng.). Nuclear Power 5, No. 50, 92-6(1960) June.

The new Windscale chemical separation process for the treatment of spent civil reactor fuel rods differs markedly from the present process which has been operated successfully for the past eight years. The new process is based on solvent extraction with tributyl phosphate diluted with an inert hydrocarbon in horizontal box-reactors. It is suitable for treating the more highly irradiated civil reactor fuels and has an efficiency superior to that of the butex process. Capital and operating costs are substantially lower. Distribution coefficient data and plant procedures are given. (auth)

16736

ON THE THERMODYNAMICS OF THE DECARBURISATION OF MOLTEN URANIUM. Rolf H. Weisser. Sulzer Tech. Rev. (Switz.) 41, No. 3, 27-32 (1960).

In the fabrication of uranium elements with zirconium canning, small amounts of carbon in the uranium are sufficient to impair the properties of the metallic bond between U and Zr. Means of reducing the carbon content of uranium during the melting process to substantially less than 0.1% were investigated. The three most obvious methods of removing carbon, i.e., oxidation to CO, combination with efficient carbide-forming agents, and hydrogenation to CH<sub>4</sub>, are shown to be impractical. As no other technically practicable decarburization processes are likely to emerge, uranium of very low carbon content must be selected from the outset for this application, and the metal must be kept out of contact with graphite surfaces during melting and casting. The difficulties involved in the use of uranium containing carbon may possibly be circumvented, without any decarburization treatment, by adopting uranium alloyed with Zr as the fissile material instead of pure uranium. There is then some hope that the carbon will be fixed in the alloy in the form of zirconium carbide, so that it is no longer able to migrate into the intermediate layer between U and Zr. (auth)

## ENGINEERING AND EQUIPMENT

### General and Miscellaneous

16737 APAE-Memo-249

Alco Products, Inc., Schenectady, N. Y. SM-2 CLUTCH TESTING. G. C. Hauenstein. Mar. 23, 1960. 49p. Contract AT(30-3)-326. OTS.

The criteria and methods for test evaluation of electromagnetic clutch characteristics are discussed. An evaluation of the relative merits of two commercial clutches, both of the multiple disk friction type, is presented with test results. One of these clutches was incorporated in the clutch assembly design for the Army Reactor (SM-2). (auth)

16738 CF-60-5-107

Oak Ridge National Lab., Tenn.

TEST OF A NATURAL-CIRCULATING HIGH-PRESSURE RECOMBINER FOR HYDROGEN AND OXYGEN. B. A. Hannaford. May 4, 1960. 16p. Contract W-7405-eng-26. OTS.

A natural-circulation loop to catalytically recombine hydrogen and oxygen at high pressure was built and operated without incident. Stoichiometric 2H<sub>2</sub> + O<sub>2</sub> electrolytically generated from 15% KOH at high pressure, was recombined on platinized wire mesh at a rate of 0.60 to 0.75 scfm at 350°C and 1500 psi total pressure for a period of 2500 hours. The concentration of stoichiometric gas ranged up to 8 mol %, the diluent being steam and excess O<sub>2</sub>. Metallurgical examination of zirconium and titanium alloys and a modified 430 stainless steel exposed in the system indicated none would be a suitable material of construction for all parts of the recombiner system, although Zircaloy-2 would be adequate for fabrication of the boiler, and the modified 430 stainless steel for the recombiner section. (auth)

16739 DP-459

Du Pont de Nemours (E. I.) & Co. Savannah River Lab., Aiken, S. C.

HYDRAULIC CHARACTERISTICS OF A CONTINUOUS SOL-

VENT WASHER WITH CRITICALLY SAFE DIMENSIONS. Harold J. Clark, Jr. and Arthur Tournas. Mar. 1960. 11p. Contract AT(07-2)-1. OTS.

The capacity of a continuous solvent washer with critically safe dimensions was found to be 0.5 gpm when either 6% or 30% tributyl phosphate in kerosene was washed with a 1 M solution of sodium carbonate. (auth)

16740 HW-53530

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

DEEPWELL TURBINE PUMP LIQUID THROTTLE BUSHING LEAKAGE. J. Dunn. Dec. 9, 1957. Decl. Mar. 28, 1960. 12p. OTS.

Leakage of process solution through the vapor throttle of deep-well turbine pumps to the outside of the process vessel occurs when the quantity of leakage past the liquid throttle bushing exceeds the ability of the slinger ring and leakage return ports to accommodate sufficient fluid. However, when external leakage is evident, over 25% of the pump capacity is lost through the liquid throttle bushing. A simple conical deflector installed below and adjacent to the lower end of the liquid throttle bushing reduces the leakage rate by at least a factor of five when the bushing is in new condition and by a factor as high as 1000 when the bushing-to-pump shaft diametral clearance is increased. An increase in over-all pump efficiency of about 1% resulted from reduction in turbulence of the solution past the end of the throttle bushing when the conical deflector was installed. (auth)

16741 NAA-SR-Memo-4850

Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.

EPOXY RESIN CONDUIT SEAL. H. Nadler. [1960]. 32p. OTS.

An epoxy resin seal was developed for a conduit penetration through the Piqua Reactor containment shell. This seal was made in a 2-in. black iron nipple (5 in. long) and prevented helium leakage through the nipple at a test pressure of 20 psig. The nipple contained neoprene-jacketed solid copper wire, or polyvinyl jacketed chromel alumel thermocouple lead wire, or 1/4-in. copper tubing. (auth)

16742 PIBAL-557

Brooklyn. Polytechnic Inst.

TEMPERATURE DISTRIBUTION AND THERMAL STRESSES IN STRUCTURES WITH CONTACT RESISTANCES. Frederick V. Pohle, T. J. Lardner, and Francis W. French. May 1960. 32p. Project No. 9782. Contract AF49(638)-302. (AFOSR-TN-60-504).

The temperature distribution in a built-up structure in the form of an I-section composed of cover plates and a web was investigated for the case of a contact resistance at the junction of the cover plates and the web. The temperature-discontinuity condition is discussed relative to proportionality to the time-derivative of the web temperature, and a new junction condition is proposed. Graphs of temperatures and stresses are presented for the case of constant flux of heat to the cover plates. (auth)

16743 SC-4403(RR)

Sandia Corp., Albuquerque, N. Mex.

NUCLEAR EXPLOSIVES AND LANDSLIDE DAMS.

Roland H. Carlson. Apr. 1960. 93p. OTS.

The possibility of constructing a rockfill dam by triggering a rockslide with nuclear explosives is explored. Seismic forces created by a deeply buried nuclear-explosive charge could initiate the slide, or the direct energy of nuclear explosives could be used to fracture the rock which would make up the slide mass. Problems discussed include

spillway construction, seepage control, and those problems unique to the utilization of nuclear explosives. Destruction of undesirable natural slide dams is also considered. Appendixes cover desirable locations for a slide dam, descriptions of naturally created slide dams, and a Russian technique for creating slide dams by direct high-explosive blasting. A cost comparison is made for a slide dam constructed by use of conventional and nuclear techniques. It is concluded that slide dams could be successfully created by means of nuclear explosives. (auth)

## 16744 UCRL-5889

California. Univ., Livermore. Lawrence Radiation Lab. ATTAINMENT OF  $10^{-8}$  mm Hg PRESSURE IN UNBAKED VACUUM SYSTEMS BY MOLYBDENUM EVAPORATION. Angus L. Hunt, Charles C. Damm, and Earl C. Popp. Feb. 25, 1960. 14p. Contract W-7405-eng-48. OTS.

The deposition of molybdenum by vaporization from simple hairpin filaments was found to reduce the pressure in an unbaked, stainless steel vacuum system to  $4 \times 10^{-10}$  mm Hg. The deposit of 300 milligrams from a single filament 0.050 inch in diameter and about 6 inches long, has maintained an 85-liter volume at a pressure below  $10^{-8}$  mm Hg for a period of over 40 hours. A small, well-trapped diffusion pump is attached to the system to attain the initial pressure of  $10^{-7}$  mm Hg and to pump the ungettered components which are presumably responsible for the ultimate pressure in the system. The geometrical area of the molybdenum substrate was  $8 \times 10^3$  cm<sup>2</sup>. The initial pumping speed of this deposit was  $4 \times 10^4$  liters per second for hydrogen. (auth)

## 16745 AEC-tr-4103

PREDICTION OF VARIOUS TUBE DEPOSITS IN COAL-FIRED BOILERS. K. Wickert. Translated from Energie 10, 267-77(1958). 29p. JCL.

In the burning of coal, all sulfurs, as water-soluble calcium, potassium, and sodium salts, are responsible for the eventual appearance of deposits on the boiler tubes. Moreover, compounds with high melting points are produced, which, although they contain oxides (e.g., SiO<sub>2</sub> and P<sub>2</sub>O<sub>5</sub>) that can be volatilized by steam, are converted into pipe deposits in the presence of enough steam and high flame temperatures. The property of the ash of the coal to cling to the pipe even at temperatures far below the melting points of the compounds also promotes the pipe deposits. That the deposits are strongly promoted is similarly true for the partially melted compounds (e.g., from Na<sub>2</sub>SO<sub>4</sub> and CaSO<sub>4</sub>) which also cling to the pipes. They can appear to be concentrated since new ones are able to build their ingredients from the SO<sub>2</sub> and SO<sub>3</sub> decomposition of the dust in the fire box. The results of the laboratory studies were compared with operating experience. (auth)

## 16746 NP-tr-438

THE CHARACTERISTICS OF FLUIDISED PARTICLES. IV. PARTICLE DISTRIBUTION IN FLUIDISED BEDS. T. Omae and J. Furukawa. Translated by L. Allen (U.K.A.E.A. Atomic Energy Research Establishment) from Kôgyô Kagaku Zasshi 56, 727-31(1953). 24p. JCL.

Experiments to determine the vertical particle density distribution in fluidized beds are described. An approximate empirical equation for the variation in bulk density along fluidized beds is presented. This equation shows that the slope of the curve resulting from plotting bulk density against height in the bed arises mainly from the fact that the particle sizes cover a wide range. Other aspects are also discussed. (J.R.D.)

## 16747

HYDROSTATIC GAS BEARINGS. John H. Laub (California

Inst. of Tech., Pasadena). J. Basic Eng. 82, 276-86(1960) June.

Orifice-regulated hydrostatic gas bearings offer significant advantages for instrument applications. In particular, gimbal bearings for inertial guidance systems can be designed with negligible starting torque and high stiffness, and for operation at extreme temperatures. Based on Euler's equation, expressions for the significant parameters, i.e., pressure profile, gas-flow rate, gap height, and load-carrying capacity of pad and step bearings, are developed. These parameters yield results which are in excellent agreement with experimental data. The test fixture incorporates pneumatic loading by means of a bellows-suspended piston which is prevented from cocking by an air bearing. (auth)

## 16748

TORQUE PRODUCED BY MISALIGNMENT OF HYDRODYNAMIC GAS-LUBRICATED JOURNAL BEARINGS.

J. S. Ausman (North American Aviation, Inc., Downey, Calif.). J. Basic Eng. 82, 335-41(1960) June.

A perturbation analysis is used to find the torque generated by a misaligned journal bearing (or, equivalently, to find the angular displacement of a torque-loaded journal). Results are presented graphically in terms of nondimensional parameters. (auth)

## 16749

CYCLIC OPERATION OF PRESSURE PIPING WITH  $\gamma$  HEATING. K. R. Merckx (General Electric Co., Richland, Wash.). J. Basic Eng. 82, 447-52(1960) June.

An elastic-plastic analysis is developed for an internally cooled pressure tube with uniform heat generation. This analysis extends the method of calculating the location of the elastic-plastic boundary reported by Barrie to account for the change in the plastic zone due to residual stresses which occur during cyclic operation. Numerical calculations are made for operating conditions expected to be encountered in a stainless steel pressure tube in a loop through the Engineering Test Reactor Core. The numerical results show that the radius of the initial plastic boundary decreases during subsequent loading cycles. Also, for equal maximum pressure and volumetric heat generation, the total plastic strain per operational cycle on the inner tube surface and the residual tensile stress on the outer tube surface increase when the tube wall is thickened. (auth)

## 16750

DETERMINATION OF GAS EFFUSION USING ISOTOPES. Kernenergie 1, 146-7(1958) Feb. (In German)

A radioisotope technique is given for measuring gas leak rate from an underground pipe. As indicator CH<sub>3</sub>Br<sup>82</sup> was used. A 56-meter pipe with 2-mm holes at 26 and 52 meters was arranged and buried, one hole in sand and one with loam. A gas analyzer was placed at each hole. The results show an independence on the type of earth. The sand had 4 to 5 times as much activity in each case as the loam. (T.R.H.)

## 16751

DESIGN OF HOT CELLS. [PART] II. Thomas Jaeger. Kerntechnik 2, 160-2(1960) May. (In German)

The design of hot cells combined with storage compartments and an irradiation chamber and of remote-controlled metallurgical facilities for fuel element processing is considered. (J.S.R.)

## 16752

COLLOIDAL GRAPHITE LUBRICATION. E. R. Braithwaite (Acheson Colloids Ltd., [Plymouth, Eng.]). Nuclear Power 5, No. 50, 118-20(1960) June.

Theories of colloidal graphite lubrication are discussed with the purpose of reconciling the structural (layers of graphite slipping by each other for lubrication) and sorption (adsorbed films on the graphite surface furnishing lubrication) theories. It is stated that the most important factor during the running-in of metal surfaces with graphite is the type, shape, and size of the dispersed graphite particles, and that the lubricating action of graphite lies in its anisotropic character. The main differences between the above viewpoint and that of Savage's sorption theory are discussed; the first holds for two rubbing metal surfaces with an abundant supply of graphite, while Savage's theory holds for a graphite block moving on a metal surface. (D.L.C.)

16753

France. Commissariat à l'Énergie Atomique. Centre d'Etudes Nucléaires, Saclay.

RECENT PROGRESS IN THE DESIGN AND EQUIPMENT OF HIGH-ACTIVITY LABORATORIES. R. Bazire and F. Duhamel. p.201-17 of "Health Physics in Nuclear Installations Symposium, Risø, May 25-28, 1959." (In French)

Design of high-activity laboratories combines the tasks of the civil engineer and the health physicist. This point of view has led to the creation in France of the "radioactivity engineer." The role of the radioactivity engineer in designing walls, carriers, and circulation systems and in selection of the major parameters is outlined. New ideas that have been developed and applied at the High-activity Laboratory, Saclay, the Laboratory for Examination of Irradiated Fuels, the Isotope Production Laboratory, the Hot Laboratory at Grenoble, the  $\alpha$ ,  $\beta$ ,  $\gamma$  Laboratories at Fontenay-aux-Roses, the hot mobile lab, and large  $\alpha$  cells are given as examples. New materials and equipment developed in France are briefly mentioned. (T.R.H.)

## Heat Transfer and Fluid Flow

16754 AEEW-R-28

United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Establishment, Winfrith, Dorset, England.

THE ANALOGY BETWEEN THE BUBBLING OF AIR INTO WATER AND NUCLEATE BOILING AT SATURATION TEMPERATURE. G. B. Wallis. 1960. 21p. BIS.

A basis for separate consideration of the hydrodynamic and thermal aspects of nucleate boiling is discussed. It is shown how boiling phenomena may be simulated in detail by the use of porous media to introduce air bubbles into water. Points of similarity and equivalence are described and analyzed. (auth)

16755 ANL-6170

Argonne National Lab., Ill.

HEAT TRANSFER IN THERMAL RADIATION ABSORBING AND SCATTERING MEDIA. Raymond Viskanta. May 1960. 200p. Contract W-31-109-eng-38. OTS.

The problem of heat transfer from media that absorb and scatter thermal radiation was studied analytically, and the theory of thermal radiation is presented in a form useful for application to the radiant heat transfer problems. The basic equation of radiant heat transfer which governs the radiation field in a media that absorbs, emits, and scatters thermal radiation was derived. The mathematical analogy between thermal radiation and neutron transport is pointed out, and a few illustrations of the applicability of the solutions obtained for neutron transport problems to the radiative transfer problems are given. The derivation of the

integral equations for radiant heat exchange in a general enclosure composed of a system of surfaces separated by an absorbing and scattering media are presented. The enclosure walls under consideration can reflect specularly and the scattering from the medium is not considered to be isotropic. The equation for the conservation of energy, including contributions due to thermal radiation, was derived by evaluating the energy transported into an imaginary closed surface fixed in space and then by applying Gauss's divergence theorem. The formulations developed are then used to gain insight into the problem by considering a few simple physical situations and obtaining numerical results for the grey case only. The Rosseland approximation for the radiant flux vector is employed in the study of Couette flow, and it is found that for large optical thicknesses the calculated temperature distributions agree well with those predicted by the exact formulation. Numerical solutions of the boundary layer equations for the flow of a radiating media along a wedge were obtained. The effect of radiation is to decrease the temperature gradient for both the hot and the cool walls; however, the heat transfer is affected only little. The validity of the diffusion approximation for radiation in boundary layer problems is limited, and should be used with caution only in situations where the mean free path of radiation is much smaller than the thermal boundary layer thickness. The transport of radiant energy between two parallel plates separated by an absorbing and scattering media is studied. The temperature distributions were obtained by solving the nonhomogeneous Milne integral equation of the first kind. It was found that the polynomial approximation for the black body emissive power is satisfactory for all values of the optical thickness. The transport of energy by simultaneous conduction and radiation in a one-dimensional system was considered. A nonlinear integral equation governing the temperature distribution in an absorbing media was solved, and it is shown that the temperature distribution is strongly dependent on the optical thickness of the slab and on the dimensionless parameter,  $N$ , which determines the relative role of energy transfer by conduction to that by radiation. The presence of radiation generally increases the heat transfer by conduction. (auth)

16756 CF-60-5-2

Oak Ridge National Lab., Tenn.

THERMAL RADIATIVE HEAT TRANSFER TO SPACE FROM A BODY ENCLOSED BY A SEMITRSPARENT BODY. R. J. Hefner. May 6, 1960. 20p. Contract [W-7405-eng-26]. OTS.

Bumpers were proposed for protecting space radiator systems from penetration by meteoroids. The development of equations to determine the thermal energy dissipation to space by a hot body completely enclosed by a second body is presented. The particular case of heat dissipation from space radiators enclosed within thin bumpers is considered, and the criteria for selection of bumper materials for a minimum weight radiator system are discussed. (auth)

16757 KAPL-M-S3G-RES-70

Knolls Atomic Power Lab., Schenectady, N. Y.

HFC: AN IBM 704 DIGITAL COMPUTER PROGRAM TO CALCULATE HEAT TRANSFER DATA OBTAINED FROM OUT-OF-PILE TESTS ON FUEL ELEMENTS. R. D. Burgess and C. L. Gregory. May 6, 1960. 97p. OTS.

The HFC Code was written to provide means for quickly performing routine calculations involving data obtained from experimental heat transfer programs. Parts A and B of the Code are used to provide calibration lines for the temperature-measuring instrumentation and to make the

necessary allowance for heat losses. Part C converts the experimental measurements into values of wall surface temperature and bulk fluid temperature corresponding to the various instrumented locations. Heat transfer coefficients are calculated, and then the Nusselt, Prandtl, and Reynolds numbers are determined for both the bulk fluid and the fluid in the film next to the surface. Provision is made for handling both non-boiling and boiling data. However, the treatment of the boiling data is limited to providing values of wall surface temperature from which the saturation temperature can be subtracted to yield values of  $\Delta T_{sat}$ . The engineering analysis followed in developing the code is described. A flow diagram and a listing of the FORTRAN II source program are given to show the sequence of computations as dictated by the engineering analysis. (auth)

**16758** TID-6045

University of Notre Dame, Notre Dame, Ind.

HEAT TRANSFER AND CRITICAL CONDITIONS IN NUCLEATE BOILING OF SUBCOOLED AND FLOWING LIQUIDS. Yan-Po Chang. [1960]. 45p. Contract AT(11-1)-785. OTS.

The heat transfer and the critical conditions in boiling of subcooled liquids with forced convection are considered. Both ordinary liquids ( $100 > Pr > 0.5$ ) and liquid metals ( $Pr < 0.1$ ) are considered as the heat transfer media. By introducing an equivalent thermal diffusivity, a general equation is obtained, valid from simple forced convection to the critical heat flux of nucleate boiling. When the condition approaches that of critical heat flux, the latent heat transport becomes significant. Through the application again of an equivalent thermal diffusivity and of a wave concept, the critical heat flux is determined. Comparing the result with that obtained from the mechanism of bubble agitation yields the critical superheat. Since the critical heat flux is considered as a problem of hydrodynamic stability and is investigated with respect to the local conditions, it does not depend on the orientation, the form and the dimension of the heater, but depends only on the subcooling, the velocity of flow, and the properties of the liquid. Pressure affects the values of the physical properties and, therefore, does not appear as a parameter. (auth)

**16759** AERE-Trans-847

HEAT TRANSFER IN THE BOILING OF WATER IN CONDITIONS OF FORCED CIRCULATION. E. K. Averin and G. N. Krushilin. Translated by J. B. Sykes (U.K.A.E.A. Atomic Energy Research Establishment) from p.239-71 of "Teploperedacha i Teplovoe Modelirovanie." A publication of the Academy of Sciences Press, USSR, Moscow, 1959. 35p.

Studies were carried out on the heat transfer from a hot stainless steel surface (slit channel) to boiling water under conditions of forced flow. The water velocity was varied from 0.85 to 5.5 m/sec, the pressure from 1 to 9 kg/cm<sup>2</sup>, and the specific heat flux from 0.2 kcal/m<sup>2</sup>-hr to the critical value (where burnout of the surface occurs). The data are presented in the form of extensive tables of the above variables for temperature differences between the surface and the water in the range 10 to 70°C, and graphs are given for heat flux and critical heat flux as functions of the above variables. Equations for the heat transfer coefficient and the critical heat flux are given; the critical heat flux is shown to be proportional to the 0.5 power of the water velocity. For small heat fluxes, the heat transfer increases with the water velocity, but for large heat fluxes it decreases. Experiments were also made on the effect of

steam content in water on the critical heat flux, which is shown to decrease with steam content up to 0.4 to 0.6 wt.-% and thereafter remain constant. This behavior is interpreted in terms of a transition to emulsion flow. Data are also given for heat transfer to boiling water moving in an annular gap. (D.L.C.)

**16760** NP-tr-444

THE CHARACTERISTICS OF FLUIDISED PARTICLES. V. METHODS OF CONTROLLING THE DISTRIBUTION OF PARTICLES AND BULK DENSITY IN FLUIDISED BEDS. T. Omae and J. Furukawa. Translated by L. Allen (U.K.A.E.A. Atomic Energy Research Establishment) from *Kogyo Kagaku Zasshi* 56, 824-6(1953). 15p. JCL.

Parameters of particle size and density control in fluidized beds are discussed. It is noted that particle sizes can be made uniform by efficient mixing and by the use of conical fluidization tubes. Other advantages of the use of conical fluidization tubes include prevention of channeling and blocking the gas inlet. (J.R.D.)

## Instrumentation

**16761** AECL-804

Atomic Energy of Canada Ltd., Chalk River, Ont.

PROCEEDINGS OF THE SIXTH TRIPARTITE INSTRUMENTATION CONFERENCE HELD AT CHALK RIVER, ONTARIO, APRIL 20-24, 1959. PART 4. INSTRUMENTS FOR NUCLEAR PHYSICS. J. E. Woolston and S. J. Townsend, eds. Aug. 1959. 221p. AECL.

Abstracts were prepared for 30 of 33 papers presented at the Sixth Tripartite Instrumentation Conference held at Chalk River, Ontario, on April 20 to 24, 1959. (C.J.G.)

**16762** AECL-804(p.1-24)

Los Alamos Scientific Lab., N. Mex.

REVIEW OF WORK IN NUCLEAR INSTRUMENTATION OF THE LOS ALAMOS GROUP. R. J. Watts. p.1-24 of PROCEEDINGS OF THE SIXTH TRIPARTITE INSTRUMENTATION CONFERENCE HELD AT CHALK RIVER, ONTARIO, APRIL 20-24, 1959. PART 4. INSTRUMENTS FOR NUCLEAR PHYSICS.

A review of nuclear instrumentation development at Los Alamos is given which includes transitions, printed circuits, multichannel analyzers, data-handling techniques, etc. Trends in developments reveal an increasing use of transistors, printed circuits, components potted in epoxy resin, and data-handling techniques in multichannel analyzers and allied instruments. (C.J.G.)

**16763** AECL-804(p.25-7)

Atomic Energy of Canada Ltd., Chalk River, Ont.

OUTLINE OF CHALK RIVER WORK SINCE 1956. F. S. Goulding. p.25-7 of PROCEEDINGS OF THE SIXTH TRIPARTITE INSTRUMENTATION CONFERENCE HELD AT CHALK RIVER, ONTARIO, APRIL 20-24, 1959. PART 4. INSTRUMENTS FOR NUCLEAR PHYSICS. (CRR-797-4.1).

Development work on nuclear instrumentation at Chalk River since 1956 is briefly reviewed. Problems in the development of 100-channel magnetic-core transistor kicksorter and 900-channel timesorter analyzers are discussed. (C.J.G.)

**16764** AECL-804(p.28-9)

Argonne National Lab., Lemont, Ill.

AN ELECTRONIC POSITIONAL ASSIST FOR FILM READERS. Robert N. Lewis. p.28-9 of PROCEEDINGS OF THE SIXTH TRIPARTITE INSTRUMENTATION CON-

ERENCE HELD AT CHALK RIVER, ONTARIO, APRIL 20-24, 1959. PART 4. INSTRUMENTS FOR NUCLEAR PHYSICS.

An electronic system was developed to improve the positioning system of a film reader for bubble-chamber tracks. This reader is a projector equipped with a digital position-readout system. Maximum error is 0.002 in. in the plane of the projected image. To achieve this reliably, a television monitor system was added which may be used either as a simple additional magnifier, or to produce two images in different colors, one of which is reversed. By superimposing the direct and reversed images of the point of interest, position may be determined easily and accurately. (auth)

**16765** AECL-804(p.30-3)

Argonne National Lab., Lemont, Ill.

DIRECT-CURRENT MEASURING DEVICE FOR HIGH CURRENTS. Gerhard T. Weiss. p.30-3 of PROCEEDINGS OF THE SIXTH TRIPARTITE INSTRUMENTATION CONFERENCE HELD AT CHALK RIVER, ONTARIO, APRIL 20-24, 1959. PART 4. INSTRUMENTS FOR NUCLEAR PHYSICS.

To eliminate the problems of shunts for measuring currents of thousands of amperes, a magnetic-amplifier system was used to give in effect a "d-c transformer." The current to be measured is passed through a special saturating core ("control transductor"), as is a cancelling feedback current. By using a single turn on the sense winding and many turns on the feedback winding, a substantial signal voltage was obtained while essentially no power was removed from the current to be measured. The performance achieved was an accuracy of one part in several thousand. (auth)

**16766** AECL-804(p.34-8)

Argonne National Lab., Lemont, Ill.

DIGITAL READOUT. Marvin T. Wiggins. p.34-8 of PROCEEDINGS OF THE SIXTH TRIPARTITE INSTRUMENTATION CONFERENCE HELD AT CHALK RIVER, ONTARIO, APRIL 20-24, 1959. PART 4. INSTRUMENTS FOR NUCLEAR PHYSICS.

The automatic digital readout of experimental data is briefly discussed. Descriptions are given of the systems: (1) neutron time-of-flight analyzer readout; (2) readout for 256-channel analyzer; (3) general-purpose editing and typing station; (4) multiple scaler-readout system; (5) counting system for measuring fast decays; and (6) an unattended counting-room system. (C.J.G.)

**16767** AECL-804(p.39-43)

Argonne National Lab., Lemont, Ill.

A THREE-DIMENSIONAL PULSE-ANALYZER SYSTEM. L. M. Bollinger, R. W. Schumann, et al. p.39-43 of PROCEEDINGS OF THE SIXTH TRIPARTITE INSTRUMENTATION CONFERENCE HELD AT CHALK RIVER, ONTARIO, APRIL 20-24, 1959. PART 4. INSTRUMENTS FOR NUCLEAR PHYSICS.

The design of a three-dimensional pulse-analyzer system is given in which three parameters are recorded per event. For a typical neutron experiment, these might be two pulse heights and a time of flight. Events are recorded on magnetic tape, which is started and stopped for each event to achieve tight packing density and thus allow efficient searching. The recording system, which has a dead time of 10 ms, and the search unit, which searches  $10^8$  events in less than a minute, are described. The system is transistorized and uses etched-circuit "building blocks" of general utility. (auth)

**16768** AECL-804(p.44-55)

Phillips Petroleum Co. Atomic Energy Div., Idaho Falls, Idaho.

DEVELOPMENT OF PHYSICS INSTRUMENTATION AT THE MTR. K. A. McCollom. p.44-55 of PROCEEDINGS OF THE SIXTH TRIPARTITE INSTRUMENTATION CONFERENCE HELD AT CHALK RIVER, ONTARIO, APRIL 20-24, 1959. PART 4. INSTRUMENTS FOR NUCLEAR PHYSICS.

Nuclear instrumentation design in support of physics measurements at MTR is centered on neutron cross section measurements and decay schemes. Diagrams and descriptions are given for the following: (1) 1024-channel pulse-time-partitioning system; (2) temporary storage systems for 1024-channel time analyzer and 144-channel pulse-height analyzer; (3) pulsed crystal-oscillator circuit; (4) phased-rotor stabilization system; (5) detector thickness time correction circuit; and (6) automatic gain-control circuit for linear pulse amplifier. (C.J.G.)

**16769** AECL-804(p.56-61)

Argonne National Lab., Lemont, Ill.

FAST COUNTING EQUIPMENT AT ARGONNE. Robert J. Epstein. p.56-61 of PROCEEDINGS OF THE SIXTH TRIPARTITE INSTRUMENTATION CONFERENCE HELD AT CHALK RIVER, ONTARIO, APRIL 20-24, 1959. PART 4. INSTRUMENTS FOR NUCLEAR PHYSICS.

The fast counting equipment used or under development at Argonne National Laboratory is described. Descriptions are given of the following: (1) proportional-counter system for reactor start-up; (2) Compton spectrometer with automatic energy scan; (3) coincidence system for studying excited states with short life, employing photomultiplier gating; and (4) instrumentation for neutron parity experiment. (C.J.G.)

**16770** AECL-804(p.62-70)

California. Univ., Livermore. Lawrence Radiation Lab.

RECENT COUNTING INSTRUMENTATION AT LIVERMORE. Robert C. Kaifer. p.62-70 of PROCEEDINGS OF THE SIXTH TRIPARTITE INSTRUMENTATION CONFERENCE HELD AT CHALK RIVER, ONTARIO, APRIL 20-24, 1959. PART 4. INSTRUMENTS FOR NUCLEAR PHYSICS. (UCRL-5543).

A review is presented of counting instrumentation development at Lawrence Radiation Laboratory. A circuit diagram and performance of a transistorized photomultiplier preamplifier are contained. A description and diagram of a running summer are given. The development of negative-feedback circuits based on the methods of Eppstein and de Waard is discussed. (C.J.G.)

**16771** AECL-804(p.71-3)

Oak Ridge National Lab., Tenn.

TRANSISTOR SWITCHING CIRCUITS. F. M. Porter. p.71-3 of PROCEEDINGS OF THE SIXTH TRIPARTITE INSTRUMENTATION CONFERENCE HELD AT CHALK RIVER, ONTARIO, APRIL 20-24, 1959. PART 4. INSTRUMENTS FOR NUCLEAR PHYSICS.

A set of transistor circuits was developed to perform the basic logical functions in digital systems. The circuits operate at speeds in excess of 1 MHz and permit five outputs from each unit with isolation between the circuit branches. Signal levels are 4 v and either d-c or a-c logic may be used. Surface-barrier transistors are used, but switching-type transistors may be substituted with equally good performance. The circuits were incorporated in a multichannel pulse-height analyzer and in a tester for barrier-grid storage tubes. (auth)

**16772 AECL-804(p.74-6)**

Du Pont de Nemours (E. I.) & Co. Savannah River Plant, Aiken, S. C.

TRANSISTORS IN COUNTING CIRCUITS. L. C. Bancroft. p.74-6 of PROCEEDINGS OF THE SIXTH TRIPARTITE INSTRUMENTATION CONFERENCE HELD AT CHALK RIVER, ONTARIO, APRIL 20-24, 1959. PART 4. INSTRUMENTS FOR NUCLEAR PHYSICS.

The performance of silicon transistors in pulse-amplifiers and count-rate circuits is discussed. (C.J.G.)

**16773 AECL-804(p.77-80)**

Atomic Energy of Canada Ltd., Chalk River, Ont.

A TRANSISTOR AMPLIFIER FOR USE WITH METHANE PROPORTIONAL COUNTERS. J. B. S. Waugh. p.77-80 of PROCEEDINGS OF THE SIXTH TRIPARTITE INSTRUMENTATION CONFERENCE HELD AT CHALK RIVER, ONTARIO, APRIL 20-24, 1959. PART 4. INSTRUMENTS FOR NUCLEAR PHYSICS. (CRR-797-4.5).

A transistor amplifier for use with methane proportional counters is described. The slope of the plateau in the curve of counting rate vs. counter voltage was 0.1% per 100 v for about 400 v at a counting rate of  $3.4 \times 10^4$  counts/sec. (C.J.G.)

**16774 AECL-804(p.88-94)**

Oak Ridge National Lab., Tenn.

A 2048-CHANNEL NEUTRON-TIME-OF-FLIGHT ANALYZER EMPLOYING MAGNETIC-CORE STORAGE. N. W. Hill and J. B. Davidson. p.88-94 of PROCEEDINGS OF THE SIXTH TRIPARTITE INSTRUMENTATION CONFERENCE HELD AT CHALK RIVER, ONTARIO, APRIL 20-24, 1959. PART 4. INSTRUMENTS FOR NUCLEAR PHYSICS.

A 2048-channel neutron-time-of-flight analyzer was developed and built for use with the Oak Ridge fast chopper and 180-m flight path. Six channel-widths from 0.25 to 8  $\mu$ s are provided. Up to four detectors may be used with the memory capacity divided equally. Provision is made for automatic operation with a sample changer. In this mode data may be stored alternately in separate parts of the memory. Each channel has a capacity of 65,535 counts. The analyzer can store more than one count per burst within the limitation of its 16- $\mu$ s storage time. Delays of up to 8192 channel-widths may be selected in blocks of 256. The data are displayed on a 5-in. oscilloscope. The entire 2048 channels or individual blocks of 256 channels may be viewed. A punched-tape output is provided for processing by the digital computer ORACLE. Vacuum tubes and large etched-circuit boards are used with the exception of the transistor-regulated power supplies. (auth)

**16775 AECL-804(p.95-7)**

Oak Ridge National Lab., Tenn.

NEUTRON-SHUTTER SPEED CONTROL. B. C. Behr. p.95-7 of PROCEEDINGS OF THE SIXTH TRIPARTITE INSTRUMENTATION CONFERENCE HELD AT CHALK RIVER, ONTARIO, APRIL 20-24, 1959. PART 4. INSTRUMENTS FOR NUCLEAR PHYSICS.

Through the use of a sampled-data closed-loop feedback system, the rotational velocity of a neutron shutter in time-of-flight spectroscopy is controlled at any pre-selected speed in the range from 100 to 15,000 rpm. Speed information accumulated by a digital counter during a one-second sampling period is compared with a preselected speed reference. Voltage differences between actual and preselected speeds control power transistors in the armature of the shutter drive motor so as to reduce the difference to zero. Maximum deviation from

preselected speed during approximately 8000 operational hours was  $\pm 1$  rpm. (auth)

**16776 AECL-804(p.98-100)**

Oak Ridge National Lab., Tenn.

FISSION-FRAGMENT TIME-OF-FLIGHT SPECTROMETER. W. H. White, Jr. p.98-100 of PROCEEDINGS OF THE SIXTH TRIPARTITE INSTRUMENTATION CONFERENCE HELD AT CHALK RIVER, ONTARIO, APRIL 20-24, 1959. PART 4. INSTRUMENTS FOR NUCLEAR PHYSICS.

A spectrometer for time-of-flight measurements of fission fragments over a 4-m path is described which provides a maximum expected time-of-flight of 500-ns to be broken into 100 channels with a resolution of 3 ns or better. Dual analyzers are provided to measure the time of flight of both daughter products in flight paths at 180°. One flight path includes an energy-selection magnet. Time values between the detector pulses at the end of the flight path (detectors 1 and 2) and the delayed pulse given by the fission event (detector 0) are converted to a time-proportional voltage pulse by Neiler's circuit. Slow pulses from all three detectors provide a coincidence signal to start analysis of the voltage pulses. Andrew's type HO transmission line is used as delay and signal cable in all three fast detector outputs. (auth)

**16777 AECL-804(p.101-10)**

Oak Ridge National Lab., Tenn.

LARGE-OUTPUT TIME-TO-VOLTAGE CONVERTER FOR HIGH COUNTING RATES. D. G. Maeder. p.101-10 of PROCEEDINGS OF THE SIXTH TRIPARTITE INSTRUMENTATION CONFERENCE HELD AT CHALK RIVER, ONTARIO, APRIL 20-24, 1959. PART 4. INSTRUMENTS FOR NUCLEAR PHYSICS.

A time-of-flight measuring apparatus was designed for neutron experiments with a pulsed Van de Graaff generator. It differs from conventional time-to-amplitude converters in that it produces a d-c output large enough to feed directly into a multichannel sorting device. Separate amplifiers and pulse stretchers between the time conversion and the voltage measurement are thus eliminated. The converter itself has the features of a precision pulse stretcher, and it cancels the stretching period for those events whose delay time exceeds a certain  $T_{max}$ . For such events, dead-time is reduced to  $T_{max} + T_{reset}$ , whereas the conventional arrangement would be overloaded. Since practically all operations are performed by d-c coupled logical circuitry, time-conversion factor and stretching period may be chosen arbitrarily in a wide range. At present conversion factors of 3, 6, 12, 24, and 48 ns/v are available and with the output scan set at 67 v, correspond to a selection of  $T_{max}$  from 200 ns to 3.2  $\mu$ s. Resolution is 2.3 ns full width at half maximum, as tested with  $Na^{22}$  annihilation coincidences using fast scintillators, and independent of the length of delay cable inserted in the "Stop" channel up to at least 120 ns. Factors governing linearity, long-term stability, maximum useful stretching time, compensation of the "walk" effect, and behavior at  $>10,000$  ct/s are discussed. (auth)

**16778 AECL-804(p.111-16)**

Oak Ridge National Lab., Tenn.

CIRCUITS RECENTLY ADDED TO DELAY-LINE MEMORY PULSE SPECTROMETER. D. C. Maeder. p.111-16 of PROCEEDINGS OF THE SIXTH TRIPARTITE INSTRUMENTATION CONFERENCE HELD AT CHALK RIVER, ONTARIO, APRIL 20-24, 1959. PART 4. INSTRUMENTS FOR NUCLEAR PHYSICS.

The addition of circuitry to a quartz-delay-line 120-

channel pulse spectrometer is discussed. The binary adding circuit was changed so that it can add or subtract pulses. Complementing the memory contents is unnecessary with this circuit. Circuitry was added that allows the memory to be split into odd and even channels for accumulating two different spectra. A gate was provided that will pass pulses only during the live time of the spectrometer. The use of this gate with an external clock provides automatic dead-time correction. A Shannon-type digital-to-analog converter was constructed with a switch to select between analog display or the original binary display. Linearity and reproducibility of analog readings of  $\pm 3\%$  are achieved. (auth)

**16779** AECL-804(p.117-22)

Oak Ridge National Lab., Tenn.

A PULSE CROSSOVER PICKOFF GATE FOR USE WITH A MEDIUM-SPEED COINCIDENCE CIRCUIT. E. Fairstein, T. A. Love, and R. W. Peelle. p.117-22 of PROCEEDINGS OF THE SIXTH TRIPARTITE INSTRUMENTATION CONFERENCE HELD AT CHALK RIVER, ONTARIO, APRIL 20-24, 1959. PART 4. INSTRUMENTS FOR NUCLEAR PHYSICS.

A gate circuit was devised that produces a pulse when the output signal from a double-line amplifier crosses the baseline. The "walk" of the output pulse relative to the start of the amplifier input signal can be less than 10 ns when using a DD2 amplifier over the output range of 5 to 100 v, and less than 5 ns over the range 10 to 100 v. The walk is not affected by mean counting rates up to  $10^5$  ct/s. The baseline crossing was established by taking advantage of the hysteresis effect in a Schmitt trigger circuit. (auth)

**16780** AECL-804(p.123-31)

Oak Ridge National Lab., Tenn.

MAGNETIC-CORE CIRCUIT DESIGN FOR THE RELIABLE PRODUCTION OF SINGLE PULSES FROM CONTACTS. R. J. Klein. p.123-31 of PROCEEDINGS OF THE SIXTH TRIPARTITE INSTRUMENTATION CONFERENCE HELD AT CHALK RIVER, ONTARIO, APRIL 20-24, 1959. PART 4. INSTRUMENTS FOR NUCLEAR PHYSICS.

The design of a magnetic-core circuit for reliable production of single pulses from contacts is given. A small transformer with a square-hysteresis-loop core material and a switch with single-pole double-throw contacts form the main parts of a passive circuit that can provide a single output pulse for each operation of the switch. The transformer core saturates in one polarity when the normally open contacts close, and in the opposite polarity when the normally closed contacts close. Ideally the core, once saturated in either polarity, cannot have further flux change in that direction. A correct choice of circuit parameters can eliminate the undesirable effects of unstable breakdown and bouncing of the contacts. It is shown that there is a minimum contact current which must be maintained by the external circuit for at least the time required to saturate the magnetic core. Condenser discharge is used to provide the necessary current for this short period while no steady-state current is required from the supply. An RC integrator is required in the transformer output circuit to minimize the false pulses that result from the small but rapid flux changes in the saturated core which result from contact bounce. (auth)

**16781** AECL-804(p.132-9)

Oak Ridge National Lab., Tenn.

GRID CURRENT IN ELECTROMETER TUBES. E. Fairstein. p.132-9 of PROCEEDINGS OF THE SIXTH TRIPARTITE INSTRUMENTATION CONFERENCE HELD AT CHALK RIVER, ONTARIO, APRIL 20-24, 1959. PART 4. INSTRUMENTS FOR NUCLEAR PHYSICS.

The performance of triode and pentode electrometer tubes in terms of grid current and yield was investigated. For all tubes the grid voltage varied as the fourth power of the triode-connected plate voltage between 5 and 10 v. The variation increased to fifteenth power between 14 and 20 v and decreased to the three-halves power above 50 v. (C.J.G.)

**16782** AECL-804(p.140-2)

Atomic Energy of Canada Ltd., Chalk River, Ont.

A LOGARITHMIC PULSE ANALYZER FOR COSMIC-RAY MEASUREMENTS. J. F. Steljes. p.140-2 of PROCEEDINGS OF THE SIXTH TRIPARTITE INSTRUMENTATION CONFERENCE HELD AT CHALK RIVER, ONTARIO, APRIL 20-24, 1959. PART 4. INSTRUMENTS FOR NUCLEAR PHYSICS. (CRR-797-4.8).

A pulse analyzer with channels logarithmically spaced for use in cosmic-ray measurements is described. (C.J.G.)

**16783** AECL-804(p.143-9)

California. Univ., Berkeley. Lawrence Radiation Lab. INSTRUMENTATION FOR THE IDENTIFICATION OF ELEMENT 102. D. Mosier. p.143-9 of PROCEEDINGS OF THE SIXTH TRIPARTITE INSTRUMENTATION CONFERENCE HELD AT CHALK RIVER, ONTARIO, APRIL 20-24, 1959. PART 4. INSTRUMENTS FOR NUCLEAR PHYSICS. (UCRL-8722).

Two systems for the identification of the isotopes of transuranium elements are described. The first system incorporates a multiplex concept in which one multi-channel pulse-height analyzer processes data from a number of detectors. The second system utilizes a number of pulse-height and time-sorting analyzers to record information derived from a single detector. (auth)

**16784** AECL-804(p.150-3)

Ferranti-Packard Electric Ltd., Toronto and Atomic Energy of Canada Ltd., Chalk River, Ont.

A TRANSISTOR MAGNETIC-CORE BUFFER STORE USED AS A DE-RANDOMIZER. H. G. Reddering and T. K. Alexander. p.150-3 of PROCEEDINGS OF THE SIXTH TRIPARTITE INSTRUMENTATION CONFERENCE HELD AT CHALK RIVER, ONTARIO, APRIL 20-24, 1959. PART 4. INSTRUMENTS FOR NUCLEAR PHYSICS.

The use of a transistor magnetic-core buffer store as a de-randomizer is discussed. A system which achieves availability of all empty spaces in the buffer store to incoming codes is described. (C.J.G.)

**16785** AECL-804(p.154-61)

Atomic Energy of Canada Ltd., Chalk River, Ont.

THE AUTOMATIC READ-OUT OF DIGITAL INFORMATION FROM KICKSORTERS, SCALERS, ETC. REVIEW OF CHALK RIVER PROGRAM. W. D. Howell, J. Leng, and L. B. Robinson. p.154-61 of PROCEEDINGS OF THE SIXTH TRIPARTITE INSTRUMENTATION CONFERENCE HELD AT CHALK RIVER, ONTARIO, APRIL 20-24, 1959. PART 4. INSTRUMENTS FOR NUCLEAR PHYSICS.

Two serial digital read-out systems are described for use in nuclear experiments where a maximum speed of ten digits per second is adequate. One system is a simple digital read-out system for logging the output from a 100-channel kicksorter or involving small quantities of digital information (16 digits or less). The second system is an extension of the first to provide facilities for reading out one or more kicksorters and/or 50 digits of additional information from scalers, switches, clocks, etc. (C.J.G.)

**16786** AECL-804(p.162-70)

United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England.

SURVEY OF INSTRUMENTS FOR PHYSICS RESEARCH AT A.E.R.E. K. Kandiah. p.162-70 of PROCEEDINGS OF THE SIXTH TRIPARTITE INSTRUMENTATION CONFERENCE HELD AT CHALK RIVER, ONTARIO, APRIL 20-24, 1959. PART 4. INSTRUMENTS FOR NUCLEAR PHYSICS.

The storage circuits and logics of a 99-channel pulse-amplitude analyzer using a ferrite-matrix store are discussed. (C.J.G.)

**16787 AECL-804(p.171-6)**

United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England.

TIME-TO-AMPLITUDE CONVERTERS FOR THE NANOSECOND AND MICROSECOND RANGE. P. R. Orman and F. H. Wells. p.171-6 of PROCEEDINGS OF THE SIXTH TRIPARTITE INSTRUMENTATION CONFERENCE HELD AT CHALK RIVER, ONTARIO, APRIL 20-24, 1959. PART 4. INSTRUMENTS FOR NUCLEAR PHYSICS.

A time-to-amplitude converter, applicable to measurements in the nanosecond to microsecond regions, is described. A resolution of 8 ns is obtained with a plastic scintillator. By switching within one box, resolutions of from 0.5 to 50 ns per channel width can be handled. Switching in another box covers the range from 50 ns to 10  $\mu$ s. (C.J.G.)

**16788 AECL-804(p.177-85)**

United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England.

DATA-HANDLING SYSTEMS. K. Kandiah. p.177-85 of PROCEEDINGS OF THE SIXTH TRIPARTITE INSTRUMENTATION CONFERENCE HELD AT CHALK RIVER, ONTARIO, APRIL 20-24, 1959. PART 4. INSTRUMENTS FOR NUCLEAR PHYSICS.

Data-handling systems which record either a single quantity associated with each event or correlated parameters are discussed. The recording of such data in a digital code on a multitrack tape is discussed. (C.J.G.)

**16789 AECL-804(p.186-7)**

Atomic Energy of Canada Ltd., Chalk River, Ont.

MEASUREMENTS ON THE STABILITY OF A ZENER REFERENCE ELEMENT IN A HIGH-VOLTAGE SUPPLY. C. G. Lennox. p.186-7 of PROCEEDINGS OF THE SIXTH TRIPARTITE INSTRUMENTATION CONFERENCE HELD AT CHALK RIVER, ONTARIO, APRIL 20-24, 1959. PART 4. INSTRUMENTS FOR NUCLEAR PHYSICS. (CRR-797-4.6).

The stability of Zener diodes as reference elements in a high-voltage supply at 0 to 60°C is treated. (C.J.G.)

**16790 AECL-804(p.189-93)**

United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England.

SCALING CIRCUITS. K. Kandiah. p.189-93 of PROCEEDINGS OF THE SIXTH TRIPARTITE INSTRUMENTATION CONFERENCE HELD AT CHALK RIVER, ONTARIO, APRIL 20-24, 1959. PART 4. INSTRUMENTS FOR NUCLEAR PHYSICS.

The uses and disadvantages of the dekatron, trochotron (magnetron beam switching tube), and scaling circuits are discussed. (C.J.G.)

**16791 AECL-804(p.194-210)**

Los Alamos Scientific Lab., N. Mex.

THE MODEL-3A TRANSISTORIZED 100-CHANNEL ANALYZER. J. R. Gilland, A. H. Greenwood, and R. J. Watts.

p.194-210 of PROCEEDINGS OF THE SIXTH TRIPARTITE INSTRUMENTATION CONFERENCE HELD AT CHALK RIVER, ONTARIO, APRIL 20-24, 1959. PART 4. INSTRUMENTS FOR NUCLEAR PHYSICS.

The essential features of a transistorized 100-channel analyzer are discussed. The method of temporarily storing one pulse while another is being analyzed was followed and logics are shown of the method of doing this with transistors. Simplified schematics of the transistorized circuits for rundown, storage, etc., are shown. The instrument contains 457 transistors and is fully compatible in speed and linearity with the electron-tube analyzers that also employ temporary pulse storage. (auth)

**16792 ANL-6157**

Argonne National Lab., Ill.

SERVOMECHANISMS WITH FORCE FEEDBACK.

Robert C. Arzbaecher. May 1960. 128p. Contract W-31-109-eng-38. OTS.

A class of linear proportional servomechanisms is examined in which an electrical signal proportional to output force is used to improve performance. The effect of this "force feedback" on a positional servomechanism is analyzed as well as the effect on a special type of servomechanism which reflects load forces back to the input. This latter type of servomechanism is called "force reflecting." Laboratory models of these servomechanisms were designed and constructed, and experimental data are presented in support of the analysis. (auth)

**16793 CREL-903**

Atomic Energy of Canada Ltd. Chalk River Project, Chalk River, Ont.

SEMICONDUCTOR DC AMPLIFIER AEP 1487. C. G. Lennox. Feb. 1960. 30p. (AECL-992). AECL.

A semiconductor d-c amplifier was designed with the object of achieving low drift without component selection or special temperature-balancing adjustments. Modulator and a-c-amplifier techniques were adopted in order to avoid the drifts that occur when transistors are directly coupled. The diode-ring modulator was used as the input chopper. (W.L.H.)

**16794 DP-406**

Du Pont de Nemours (E.I.) & Co. Savannah River Lab., Aiken, S. C.

NONLINEAR ANALOGUE TO DIGITAL CONVERTER. Leslie E. Goodwin. Aug. 1959. Decl. Nov. 30, 1959. 12p. Contract AT(07-2)-1. OTS.

An electromechanical instrument is described which produces a shaft rotation which is a linear function of the quantity being measured from a nonlinear input signal. The instrument was used to convert the output function of the Nuclear Test Gage (NTG) which is nonlinear with respect to fuel concentration to a form that will directly drive an automatic production recorder (APR). The output shaft is geared to a Veeder Root counter so that the value of the independent variable is given to the NTG operator in digital form. A rate-of-charge detector automatically trips the APR when the reading has come sufficiently close to equilibrium. (auth)

**16795 DP-469**

Du Pont de Nemours (E. I.) & Co. Savannah River Lab., Aiken, S. C.

A LEVEL INDICATOR FOR LIQUEFIED GASES. Arnold L. Burke and Louis H. Cook, Jr. Mar. 1960. 8p. Contract AT(07-2)-1. OTS.

A capacitance instrument is described that indicates the level of liquefied gas in a closed container. The instrument

has been used to indicate and control the level of liquid nitrogen, hydrogen, and methane. (auth)

**16796 HW-60440**

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

PROJECT CAI-816-105-N DESIGN CRITERIA—CONFINE-MENT SYSTEM INSTRUMENTATION. W. A. Richards and J. K. Flickinger. Nov. 9, 1959. 8p. Contract AT(45-1)-1350. OTS.

A description is given of the instrumentation for a reactor confinement system. A diagram of the system is contained. (C.J.G.)

**16797 KAPL-M-RAK-1**

Knolls Atomic Power Lab., Schenectady, N. Y.

INTERFERENCE TESTS OF LARGE A. C. CABLES ON THERMOCOUPLE SIGNALS. R. A. Kaufman. May 11, 1960. 20p. Contract W-31-109-Eng-52. OTS.

In order to estimate the voltages induced in D1G instrumentation cables by high-current 60 cps circulating pump supply lines, the effects of the same high-current lines on thermocouple extension cables were studied. Coupling lengths were 3 and 11 feet, and separation distances were varied from 0 to 5 inches at each coupling length. The data for the induced voltages are given. (D.L.C.)

**16798 PWAC-293**

Pratt and Whitney Aircraft Div., United Aircraft Corp., Middletown, Conn.

THREE MODELS OF EXPERIMENTAL TEMPERATURE SENSORS. C. F. Grimsey. Apr. 29, 1960. 26p. Contract NOas-58-662-c.

Design and fabrication of navy experimental temperature sensors are reported. Testing of these sensors was directed toward proving their design concepts. Results indicate that development of the units into flightworthy components is practical and feasible. (J.R.D.)

**16799 SCR-174**

Sandia Corp., Albuquerque, N. Mex.

KRYTRON TUBES—APPLICATIONS AND PERFORMANCE REQUIREMENTS. A. F. Kurford. Apr. 1960. 11p. OTS.

Three typical applications of krytron tubes are discussed along with environmental requirements. Tube requirements for future applications are also discussed. (auth)

**16800 SCTM-35-54(52)**

Sandia Corp., Albuquerque, N. Mex.

RANDOM SYNC GENERATOR. W. F. Nielsen. Mar. 9, 1954. 9p. OTS.

A device is described which provides random d-c pulses, or relay closures, which may be used to sync-modulate a standard 1000-cycle range time base through the medium of the time base modulator, for the purpose of synchronizing any number of otherwise independent records. (auth)

**16801 AEC-tr-3656**

RESEARCH IN THE FIELD OF DOSIMETRY OF IONIZING RADIATION. A Collection of Articles. (A translation of "Issledovaniya v Oblasti Dozimetrii Ioniziruyushchikh Izlucheniy." K. K. Aglntsev, ed. A publication of the Academy of Sciences, USSR Press, Moscow, 1957). 267p. OTS.

The articles included are devoted to research in the field of absolute measurements of beta-active substances, scintillation methods, and individual control instruments, and also articles devoted to the techniques of dosimetric measurements and calculations of the maximum-permissible levels of external particle fluxes. The articles were completed in 1950 to 1954. Some were reported to the 1954 Academy of Sciences USSR conference on dosimetry. (C.H.)

**16802 AEC-tr-3656(p.1-49)**

METHOD OF ABSOLUTE MEASUREMENT OF ACTIVITY OF BETA-RADIATION SOURCES WITH THE AID OF END-WINDOW COUNTERS. I. B. Keirim-Markus and M. A. L'vova. p.1-49 of "Research in the Field of Dosimetry of Ionizing Radiation." K. K. Aglntsev, ed.

Methods for counting absolute activity of beta radiation sources are reviewed. It was concluded that end-window counters give the best accuracy. Results are presented from an experimental investigation of the absorption of beta radiation in air and in mica of the counter and of the back-scattering from the substrate. A table is included which was calculated for the duration of the measurements. 51 references. (C.H.)

**16803 AEC-tr-3656(p.50-97)**

METHOD OF ABSOLUTE MEASUREMENTS OF ACTIVITY OF SOURCES OF BETA RADIATION WITH THE AID OF END-WINDOW COUNTERS. I. B. Keirim-Markus and M. A. L'vova. p.50-97 of "Research in the Field of Dosimetry of Ionizing Radiation." K. K. Aglntsev, ed.

Methods of introducing corrections for self-absorption and self-scattering during beta counting are reviewed. A method is proposed for introducing corrections for self-absorption and self-scattering which takes into account the geometrical conditions of counting. Corrections for source thickness are included. The influence of backward-scattering from the substrate on the shape of the self-absorption and self-scattering curve was also studied. 33 references. (C.H.)

**16804 AEC-tr-3656(p.98-112)**

ABSOLUTE MEASUREMENTS OF BETA ACTIVITY BY THE METHOD OF SMALL IONIZATION CHAMBERS.

I. A. Antonova. p.98-112 of "Research in the Field of Dosimetry of Ionizing Radiation." K. K. Aglntsev, ed.

Problems associated with the measurement of absolute activity of beta-active compounds are discussed. A method is described for determining the mean energies of the beta spectra. The beta-active substance is introduced in the form of an aqueous solution in gelatin, from which thimble chambers are molded. If the activity of the substance introduced into the walls of such a chamber is known, it is possible to determine from the ionization current the average energy of the beta spectra of various radioactive substances. An attempt was made to improve the method of gelatin chambers and to apply it to chambers made of solid activated substances or of mechanical mixtures of insoluble radioactive salts with gelatin. Small ionization chambers were used to determine the absolute activity of beta-active substances. (C.H.)

**16805 AEC-tr-3656(p.113-23)**

USE OF SCINTILLATORS IN DOSIMETRY. I. M. Rozman and K. G. Tsimmer. p.113-23 of "Research in the Field of Dosimetry of Ionizing Radiation." K. K. Aglntsev, ed.

Applications of scintillators in dosimetry are discussed. Examples described include a luminescent x-ray dosimeter, scintillation dosimeters for beta particles, a scintillation dosimeter for alpha particles, a scintillation dosimeter for thermal neutrons, and a scintillation dosimeter for fast neutrons. In addition to the applications of scintillation methods in dosimetry described, other possibilities are discussed. These include a glass vessel silver plated on the outside and covered on the inside with a thin layer of zinc sulfide for use in measuring the radioactivity of gases. A whole-body counter for the human body is described which consists of a tub in which the patient is seated, which is placed in a larger tub with a liquid scintillator and the luminescence of this scintillator is measured with the aid

of from 50 to 200 photomultipliers. It is concluded that the use of scintillation methods does not offer a universal method for solving dosimetric problems but in many cases scintillation methods give better results and scintillation dosimeters are simpler and more convenient. 50 references. (C.H.)

**16806** AEC-tr-3656(p.124-35)

LUMINESCENT ISODOSOGRAPH. I. M. Rozman and K. G. Tsimmer. p.124-35 of "Research in the Field of Dosimetry of Ionizing Radiation." K. K. Aglntsev, ed.

This paper was previously abstracted from the original language and appears in NSA, Vol. 12, as abstract No. 9965.

**16807** AEC-tr-3656(p.136-41)

EXPERIMENTAL DATA ON THE LUMINESCENCE METHOD OF DOSIMETRY OF GAMMA RADIATION. I. E. (Ye.) Konstantinov. p.136-41 of "Research in the Field of Dosimetry of Ionizing Radiation." K. K. Aglntsev, ed.

An abstract of this paper was previously translated from the original language and appears in NSA, Vol. 13, as abstract No. 22299.

**16808** AEC-tr-3656(p.142-53)

INDICATING POCKET GAMMA-DOSIMETERS. M. I. Amiraguva, V. Ye. Busygina, and Yu. M. Shtukkenberg. p.142-53 of "Research in the Field of Dosimetry of Ionizing Radiation." K. K. Aglntsev, ed.

The design, construction, and performance are described of a pocket dosimeter for the direct reading of gamma dosage. The dosimeter is the size of a fountain pen and includes a small ionization chamber and an electrometer, the measuring system of which is the collecting electrode of the ionization chamber. The deviation of a movable system is measured with a reading microscope equipped with a scale, graduated into roentgens. (C.H.)

**16809** AEC-tr-3656(p.154-6)

POCKET GAMMA RADIATION DOSIMETER. M. Ardenne, G. Yeger, B. Roggenbuk, and G. Froylikh. p.154-6 of "Research in the Field of Dosimetry of Ionizing Radiation." K. K. Aglntsev, ed.

A pocket electrometer is described which was designed for use as a gamma dosimeter in semi-industrial work. A cross-section sketch is included. (C.H.)

**16810** AEC-tr-3656(p.157-63)

APPARATUS FOR INDIVIDUAL DOSIMETRIC CHECKING. A. A. Pavlov, I. M. Rozman, and K. G. Tsimmer. p.157-63 of "Research in the Field of Dosimetry of Ionizing Radiation." K. K. Aglntsev, ed.

The design of radiation dosimeters which cover a wide dosage range is described. Two condensing chambers with different air volumes are positioned in one casing. The two chambers, in conjunction with the charging-measuring appliance, overlap the range of 0 to 350 mr and 0 to 5 r. Drawings are included of a longitudinal cross section of the chamber and the circuit of the tube electrometer. (C.H.)

**16811** AEC-tr-3656(p.164-5)

POCKET TYPE GAMMA INDICATOR. F. K. Levochkin. p.164-5 of "Research in the Field of Dosimetry of Ionizing Radiation." K. K. Aglntsev, ed.

The design is described of a pocket-type gamma indicator intended for the determination of the presence of gamma radiation and for a tentative estimate of the dose intensity with a field range from the natural background to several tens of mr/sec. A diagram of the instrument is included. In the presence of gamma radiation the number of discharges produced in the counting tube is high compared with background and these discharges are determined

from the flashes of two neon tubes. The instrument is calibrated with the aid of a gamma source and a table is compiled from which to determine the relation between the dose intensity in mr/sec and the number of flashes of the neon tubes. (C.H.)

**16812** AEC-tr-3656(p.166-81)

IMPROVED METHOD FOR INDIVIDUAL PHOTOCONTROL OF GAMMA DAMAGE (IFK-II). N. S. Nikitin and V. V. Frolov. p.166-81 of "Research in the Field of Dosimetry of Ionizing Radiation." K. K. Aglntsev, ed.

The use of compensating filters and intensifying screens was found to increase the energy range and sensitivity of photographic film radiation detectors. A new modification of the cassette is described which makes it possible to solve the problem of marking the film and accelerates considerably the processing of the photofilm. (C.H.)

**16813** AEC-tr-3656(p.182-208)

AN ELECTROFILTER FOR DETERMINING THE CONCENTRATIONS OF ACTIVE AEROSOLS. Yu. M. Shtukkenberg, K. S. Kalugin, and A. I. Bobkov. p.182-208 of "Research in the Field of Dosimetry of Ionizing Radiation." K. K. Aglntsev, ed.

Design features are described of a portable electrofilter for determining the concentration of alpha- or beta-active aerosols in the atmosphere. Schematic sketches of the electrofilter are included. The mechanism of the deposition of dust particles in an electrofilter is discussed in detail. Methods are described for determining the efficiency of the electrofilter. (C.H.)

**16814** AEC-tr-3656(p.209-19)

MEASUREMENT OF SMALL CONCENTRATION OF ALPHA-ACTIVE SUBSTANCES IN WATER WITH THE AID OF A DIFFUSION CLOUD CHAMBER. V. I. Popov. p.209-19 of "Research in the Field of Dosimetry of Ionizing Radiation." K. K. Aglntsev, ed.

An abstract of this paper was previously translated from the original language in NSA, Vol. 13, as abstract No. 22300.

**16815** AEC-tr-3656(p.220-4)

SPARK COUNTER FOR CONTROL OF CONTAMINATION OF SURFACES BY ALPHA-ACTIVE SUBSTANCES. E. (Ye.) A. Andreevich (Andreyeshchev), B. M. Isaev (Isayev), and I. F. Mel'nikov. p.220-4 of "Research in the Field of Dosimetry of Ionizing Radiation." K. K. Aglntsev, ed.

Design is described of a multiple-filament spark counter for monitoring alpha activity. The cathode has an area of 150 cm<sup>2</sup>. Sketches of the electric circuit of the counter and a cross section through the counter are included. The system of filaments and the cathode of the counter are placed on a plexiglas base, the counter cathode is made of steel, and the surface of the cathode is polished to a mirror finish. The filaments are secured and stretched by a system of screws attached on two brass plates. A great advantage of the instrument is the absence of background and the possibility of counting the alpha particles at any value of the beta or gamma background. (C.H.)

**16816** AEC-tr-3656(p.225-39)

GAMMA SPECTRUM INDICATOR. I. A. Antonova and I. V. Estulin. p.225-39 of "Research in the Field of Dosimetry of Ionizing Radiation." K. K. Aglntsev, ed.

A layered differential ionization chamber is described which was designed to analyze the gamma radiation from a source and thus determine the composition of the compound. This method uses the dependence of the ionizing action of the gamma rays on the energy of the gamma radiation and permits the solution of the problem by simple

ionization measurements. The differential chamber of the instrument consists of two separate ionization chambers in the shape of coaxial cylinders. A sketch of the indicator is included and data are tabulated on factors affecting the sensitivity of the indicator. (C.H.)

**16817** AEC-tr-3656(p.240-5)

AUTOMATIC CIRCUIT FOR THE MEASUREMENT OF WEAK CURRENTS. I. A. Antonova and I. N. Senchuro. p.240-5 of "Research in the Field of Dosimetry of Ionizing Radiation." K. K. Aglintsev, ed.

Design of a single-stage automatic circuit for measurement of weak currents is described. The measurement of the current is based on the determination of the discharge time of the input capacitor. By input capacitance is meant the sum of the capacitances of the electrometric tube, of the ionization chamber, the connecting wires, and the relay. When the instrument is connected, plate current will flow in the circuit. Applications in counting pulses are discussed. (C.H.)

**16818** NP-tr-441

EFFECT OF TEMPERATURE ON PHOTOMULTIPLIERS AND LIQUID SCINTILLATORS. G. Laustriat and A. Coche. Translated by S. Fitzgerald (U.K.A.E.A. Atomic Energy Research Establishment) from *J. phys. radium* 19, 927-9 (1958). 9p. JCL.

The effects of temperature on liquid scintillation counters are examined. It was found that during cooling the photomultipliers are most affected, resulting in reductions of background noise and pulse height increases. There seems to be less advantage in cooling the liquid scintillator because of the low temperature coefficient and other practical difficulties. (J.R.D.)

**16819** NP-tr-454

ELECTRIC MICROMACHINERY OF AUTOMATION SYSTEM. (Elektricheskie Mikromashiny Avtomaticheskikh Ustroystv). Yu. S. Chechet. Translated from a publication of the State Publishing House on Power Engineering Literature, Moscow-Leningrad, 1957. 377p. OTS.

A description is given of the basic types of electric micromachines for automatic devices: servomotors, tachometer generators, rotary transformers, and synchro-tie machines, as well as the questions of theory and practical application of the latter in automation circuits. (W.L.H.)

**16820** SCL-T-311

North Atlantic Treaty Organization, Paris. Advisory Group for Aeronautical Research and Development. EXCERPTS FROM CAPACITANCE MANOMETER FOR THE MEASUREMENT OF RAPIDLY VARYING PRESSURES. (Manomètre à Capacité pour la Mesure des Pressions Rapidement Variables). A. Moutet. Translated by Marcel I. Weinreich (Sandia Corp.) from report AGARD-171 (p.1-4). 21p. JCL.

Pressure-measuring equipment which utilizes the principle of the variation of the capacitance of a transducer subjected to a pressure was developed for measuring rapidly varying pressures. A number of transducers which gave good results in particular cases are described, and working diagrams are given. The performance of various component parts of the electronic apparatus is described. Problems of calibration are discussed. The results of applications of the equipment in the field of internal aerodynamics are given. (C.J.G.)

**16821**

SLIT HEIGHT CORRECTIONS IN SMALL ANGLE X-RAY SCATTERING. Paul W. Schmidt and Robert Hight, Jr.

(Univ. of Missouri, Columbia). *Acta Cryst.* 13, 480-3 (1960) June. (In English)

A method of correcting experimental small angle x-ray scattering curves for the effects of the height of the collimating slits is developed. The method has the advantage of eliminating the need for numerical differentiation of the experimental curve. An expression suitable for numerical calculation is given, and an analysis is made of the error in the numerical approximation. The results of some applications of these slit correction techniques are discussed. (auth)

**16822**

FAST-NEUTRON FLUX-DISTRIBUTION MEASUREMENTS ON THE CORE OF THE VVR-S REACTOR BY MEANS OF THE CONDUCTIVITY CHANGE IN GERMANIUM. E. Aleksandrovich and M. Bartenbach (Inst. of Nuclear Research, Polish Academy of Sciences, Warsaw). *Atomnaya Energ.* 8, 451-2(1960) May. (In Russian)

Variations of germanium monocrystal conductivity with fast neutron irradiation are plotted as a function of time. Measurements were made on nine parallelepipeds  $1.5 \times 1.5 \times 10$  mm specimens placed at various depths in the core of a water-cooled water-moderated reactor. The largest variations were observed in  $d\sigma/dt$  at  $t = 1$  hour and  $t = 2$  hours. The distribution of fast neutron flux along the active zone is shown. (R.V.J.)

**16823**

USE OF SCINTILLATION COUNTERS TO DISCRIMINATE AGAINST SCATTERED RADIATION IN  $\gamma$ -RAY SPECTROSCOPY. V. E. Nesterov. *Atomnaya Energ.* 8, 461-3(1960) May. (In Russian)

Descriptions are given of an experimental transistorized field-type scintillation spectrometer with outside dimensions of only 44 mm. Field tests proved satisfactory. (R.V.J.)

**16824**

A COMPTON-ELECTRON  $\gamma$ -SPECTROMETER WITH TWO-DIRECTIONAL FOCUSING. G. E. Lee-Whiting (Atomic Energy of Canada Ltd., Chalk River, Ont.). *Can. J. Phys.* 38, 720-50(1960) June.

Improvements in the design of one type of Compton-electron spectrometer for  $\gamma$ -rays are proposed. The design requires a magnetic field of cylindrical symmetry and of slow radial variation, a simply curved radiator, and a system of apertures. Electrons are accepted only if they are ejected from the radiator with small components of momentum in two orthogonal directions perpendicular to the incident  $\gamma$ -ray. Since the magnetic field can be used to measure the momentum of the selected electrons, the instrument can function as a  $\gamma$ -ray spectrometer. Higher-order aberrations are discussed, and a method of calculating the values of the various spectrometer parameters corresponding to maximum efficiency is given. Calculations of the intrinsic line-width, caused by the motion of the electron within the atom before collision with the photon, are carried out. (auth)

**16825**

AN IMPROVED ELECTROSTATIC ELECTRON SELECTOR. Paul Marmet and Larkin Kerwin (Laval Univ., Quebec). *Can. J. Phys.* 38, 787-96(1960) June.

A cylindrical electrostatic electron selector is described which provides a  $10^{-7}$  amp beam of electrons whose energy may be varied from 0 to 50 ev and whose energy spread is less than 100 mv. Space-charge problems involved in the construction of the device were overcome by the use of grids for focusing electrodes with exterior

electron traps, and a non-reflecting surface for electrons made from a network of tiny tubes. The selector is provided with an energy analyzer. When used to determine the appearance potential curve of argon, the selector resolved the  $2P_{3/2}$  and  $2P_{1/2}$  states separated by 0.18 ev, and indicated the formation of  $Ar^+$  at an energy of 0.8 ev below the threshold for  $Ar^+$ . (auth)

16825

INTERNAL PAIR ANGULAR CORRELATION SPECTROMETER FOR DETERMINATION OF  $\gamma$ -RAY MULTIPOLARITIES. G. A. Bartholomew (Atomic Energy of Canada Ltd., Chalk River, Ont.). *Can. J. Phys.* 38, 871-7 (1960) June.

The angular correlation between the positive and negative electrons produced by  $\gamma$ -ray internal pair conversion is an index of the multipolarity of  $\gamma$ -ray transition. The possible advantages possessed by a certain design of 180° flat pair spectrometer are pointed out, which may be used for measuring this correlation under conditions of good energy resolution, of the order of 1%. Modifications of an existing pair spectrometer are being made for this purpose. (B.O.G.)

16827

THE BEHAVIOR OF A NON-LINEAR TRANSISTORIZED AMPLIFIER IN THE VICINITY OF ITS STABILITY LIMIT. Igor Gumowski. *Compt. rend.* 250, 3142-4 (1960) May 9. (In French)

It is shown that a homogeneous differential-functional equation of the first order can admit a periodic solution. The conditions of existence of this periodic solution permit the stability limit of the amplifier to be established. (tr-auth)

16828

PULSE GENERATOR FOR SYNCHRONIZING EVENTS. R. E. Daniels and C. Swoboda (Argonne National Lab., Lemont, Ill.). *Electronics* 33, No. 24, 63 (1960) June 10.

A transistorized pulse generator for timing pulses was developed for the operation of a 12.5-Bev proton synchrotron. It will operate when triggered with an input of 5 volts or more (either negative or positive) whose rise time is more than 2 volt/ $\mu$ sec. The output to a 90-ohm load is an isolated pulse with a width of  $1 \pm 0.4$   $\mu$ sec, rise and fall times of 0.2  $\mu$ sec, less than 10% droop with the 90-ohm load, and less than 5% overshoot on open circuit. The maximum repetition rate is 40 Kc. (D.L.C.)

16829

PROTON VECTOR MAGNETOMETER. L. Hurwitz and J. H. Nelson (U. S. Coast and Geodetic Survey, Washington, D. C.). *J. Geophys. Research* 65, 1759-65 (1960) June.

Z and H, as well as F, were measured at the Fredericksburg Magnetic Observatory with a proton vector magnetometer, combining a proton-precession intensity magnetometer and a Helmholtz coil system mounted on a horizontal circle. Formulas for the effect of various instrumental adjustments are given without proof; the only critical adjustment is the level of the horizontal circle (magnetometer base). The internal consistency of the observed values  $Z_p$ ,  $F_p$ , and  $H_p$  is indicated by the smallness of computed values  $H_p - (F_p^2 - Z_p^2)_{1/2}$ ; these values are less than 3  $\gamma$  in magnitude and have a mean of 0.4  $\gamma$ . Preliminary results of comparisons with the observatory sine galvanometer and earth inductor are: PVM-SG (measurements of H) = 2.7  $\gamma$ , PVM-EI (measurements of dip) = 1". The source of the H difference is now being investigated. (auth)

ards, Washington, D. C.). *J. Opt. Soc. Am.* 50, 651-6 (1960) July.

A sealed-off atomic-beam light source which utilizes the single isotope  $Hg^{198}$  is described. The emitted 2537 Å line was investigated interferometrically with Fabry-Perot interferometers. Interferograms are shown for retardations of 0.4, 1.53, and 2.04 m with order numbers 1.6, 6.0, and 8.1 million, respectively. For each retardation, the theoretical contour of the observed fringes is shown. Theoretically predicted fringe contours are shown for retardations up to 6 m, the approximate limit of interference. It is concluded from the interferograms that the  $Hg^{198}$  2537 Å line has a half width of  $0.0016 \text{ cm}^{-1}$ , as compared to  $0.012 \text{ cm}^{-1}$  for the  $Kr^{86}$  6056 Å line proposed as the new primary standard of length. Owing to the small half-width and the extremely low level of perturbation in the atomic beam, this  $Hg^{198}$  line would be suitable for the primary standard of length. (auth)

16831

RAPID PRECISION WAVE NUMBER MEASUREMENTS FROM FABRY-PEROT INTERFEROGRAMS. David W. Steinhaus (Los Alamos Scientific Lab., N. Mex.). *J. Opt. Soc. Am.* 50, 672-5 (1960) July.

In order to obtain the more accurate wave numbers needed for studies of the very rich heavy element spectra, a new measuring and calculating procedure was developed. A modern sharp line source, such as a hollow cathode discharge or an electrodeless metal-halide lamp, is used to illuminate a vacuum Fabry-Perot interferometer (5, 10, or 20 mm spacer). The interferometer is crossed with a spectrograph resolving the free spectral range of the interferometer. The resulting interferogram is measured with a two-coordinate photoelectric comparator. The measurements are punched on IBM cards, and vacuum wave numbers are directly calculated with a high-speed digital computer. Only one standard line is needed and the index of refraction of air correction is used only to obtain air wavelengths. The phase change correction is obtained from measurements with two different spacers or from measurements on several standard lines. Only a few minutes reading time are needed for each line. This procedure is being used for a further study of the uranium spectrum with sources containing separated uranium isotopes. Over 8000 lines near 4100 Å have been measured with a precision better than  $0.005 \text{ cm}^{-1}$ . (auth)

16832

THE USE OF THE CZECHOSLOVAK OPTICAL GLASSES FOR THE INDUSTRIAL DOSIMETRY. Zdeněk Spurný (Inst. of Nuclear Physics, Czechoslovak Academy of Sciences, Prague). *Jaderná energie* 6, 163-5 (1960). (In Czech.)

Results are given of the investigation of glass dosimeters. The sensitivity of 12 samples of Czechoslovak optical glasses to x and gamma radiation and the correction of the fading were investigated, and dosimetry of a strong  $Co^{60}$ -source was made. (auth)

16833

DETERMINATION OF THE ABSOLUTE COUNT OF NEUTRONS FROM A RADIUM-BERYLLIUM SOURCE BY COMPARISON WITH A PHOTONEUTRON-DEUTERIUM SOURCE. K. A. Petržák, M. A. Bak, and B. A. Fersman. *Kernenergie* 1, 99-104 (1958) Feb. (In German)

A comparatively simple and easy to use laboratory method was developed for calibration of neutron sources. A photoneutron-D source is used as the original neutron standard, which consists of a container filled with heavy water into the center of which a  $\gamma$  source is put. The num-

16830

SEALED-OFF  $Hg^{198}$  ATOMIC-BEAM LIGHT SOURCE. R. L. Barger and K. G. Kessler (National Bureau of Stand-

ber of photoneutrons from this source is determined on the basis of the absolute count of photoprottons which form in a deuterium gas ionization chamber. The ionization chamber has uniform geometry and is irradiated under the same conditions as the original neutron standard. The comparison of intensity of the original standard with the source to be calibrated was done using the surface under the curve of the spatial distribution of neutrons slowed down in water. The method is applied to determination of the absolute count of neutrons emitted by a Ra- $\alpha$ -Be source. (tr-auth)

16834

DETERMINATION OF THE INTENSITY OF NEUTRON SOURCES BY MEANS OF ACTIVITY INDUCED IN POTASSIUM PERMANGANATE SOLUTION BY NEUTRONS.

V. A. Davidenko and A. M. Kučer. *Kernenergie* 1, 110-11(1958) Feb. (In German)

The intensity of a Ra- $\alpha$ -Be source was measured on the basis of the neutron-induced activity in an aqueous  $\text{KMnO}_4$  solution. The main part of the  $\text{Mn}^{58}$  activity, which resulted from capture of neutrons slowed down by the water, was in the form of  $\text{MnO}_2$  separated out by ordinary filtration. To take into consideration the neutrons captured by hydrogen, the ratio of thermal neutron capture cross sections of Mn to H was determined to be  $41 \pm 2$ . It was found that the intensity of the two sources studied was  $10,600 \pm 500$  neutrons/sec for 1 mg Ra. (tr-auth)

16835

DETERMINATION OF THE AXIS OF A GAMMA-RAY BEAM WITH A SECTOR IONIZATION CHAMBER. *Kernenergie* 1, 318-20(1958) Apr. (In German)

A 4-sector ionization chamber is described for finding the axis or center of a  $\gamma$  ray beam. The sectors are quadrants of a circle and the currents from all four are equal when the beam is in the center. (T.R.H.)

16836

NEUTRON FLUX MEASUREMENT AT ELEVATED TEMPERATURES. A. L. Gray (Plessey Nucleonics, Ltd., Northampton, Eng.). *Nuclear Eng.* 5, 245-8(1960) June.

The problems of neutron flux measurements in high-temperature, low-flux (zero-energy) reactors are discussed. Because of the low flux, the detectors must operate closer to the core than in power reactors and hence must withstand higher temperatures for long periods of time. Gas ionization detectors are chosen as being the only type practicable under the above conditions, and the problems associated with their construction are outlined: envelopes and electrode structures, insulators, vacuum lead-through seals (ceramics are substituted for glass), neutron-sensitive media, gas fillings, and signal leads, the last being one of the most difficult problems. Space limitations (small core, etc.) also impose further restrictions on the design. At present, ionization chambers for use at  $400^\circ\text{C}$  and fission counters for use up to  $900^\circ\text{C}$  can be made; a design for a 1.5-in. stainless steel ionization chamber built for Harwell is given. (D.L.C.)

16837

RADIATION AND ELECTRONIC DESIGN. P. Barratt (Pye, Ltd., Cambridge, Eng.). *Nuclear Eng.* 5, 251-4 (1960) June.

The factors involved in designing in-pile TV equipment for radiation resistance to gamma photons and neutrons are discussed. Under irradiation, the equipment must continue to operate, to have no effect on reactor operation, and to have low induced radioactivity. Susceptibilities to radiation damage are given for different materials: metals, inorganic and organic compounds, and semiconductors.

The behavior of electronic components, e.g., capacitors, upon neutron irradiation is given. Some irradiation experiments were performed on an experimental TV circuit; it was possible to use the circuit for two hours after integrated thermal neutron doses of  $10^{16}/\text{cm}^2$  or less with some degradation in picture quality. After only 2 or 3 weeks of cooling, the irradiated equipment could be handled. (D.L.C.)

16838

THE RECORDING OF NUCLEAR PULSE DATA. P. E. Cavanagh (United Kingdom Atomic Energy Research Establishment, Harwell, Berks, Eng.). *Nuclear Eng.* 5, 255-7(1960) June.

Recording of pulse data enables analysis of the data to be done some time after the experiments have been performed. Methods of recording which permit direct feed into a conventional pulse analyzer are magnetic and digital tape recording. The type of magnetic recording used is analog, i.e., amplitude modulation of tape magnetization. Pulses may be recorded with the tape moving very slowly and playback then done at normal tape speed, thus producing speed-up factors up to 1,000 to 1. This method of recording is suitable for low-energy applications where detector resolution is not very high, e.g., scintillation spectrometry of  $\beta$  and  $\gamma$  rays. When the data are in digital form and accuracy is required, as in neutron spectrometry, digital recording is preferred; however, it is necessary to use higher tape speeds on the order of 100 in./sec so that some speed-up can be obtained. Digital recording provides higher resolution and can be used to advantage in analysis of complex correlation data. It is concluded that use of the two recording methods will increase. (D.L.C.)

16839

A NEW DESIGN FOR A BETA-RAY SPECTROGRAPH FOR RELATIVE MEASUREMENTS. Erik Karlsson and Kai Siegbahn (Univ. of Uppsala). *Nuclear Instr. & Methods* 7, 113-23(1960) May. (In English)

A new semicircular beta-spectrograph is described. The focusing field is obtained from a well-stabilized electromagnet. The instrument is provided with special arrangements for careful relative measurements. The energy calibration can be made reproducible by means of a special source exchange arrangement. The recording film can be exposed by sections along its length. Resolution and transmission characteristics are discussed and a method for using mass-separated sources is presented. (auth)

16840

A  $4\pi$ -FISSION DETECTOR. A. Deruytter (Centre d'Etude de l'Energie Nucléaire, Mol, Belg.). *Nuclear Instr. & Methods* 7, 145-52(1960) May. (In English)

A technique was developed to prepare fission foils of uniform thickness on thin plastic films (VYN-3) coated with Al, to be used as a cathode inside a  $4\pi$  chamber. The optimum thickness of the Al-coating is  $2.5 \mu\text{g}/\text{cm}^2$  on both sides of the film. These films are brought in an ionization chamber filled with a mixture of 98% Ar and 2%  $\text{N}_2$ . The influence of the thickness of the  $\text{U}^{235}$ -film on the discrimination between fission and alpha pulses was studied. The evaluated efficiency of the counter for a  $1 \text{ mg}/\text{cm}^2 \text{ U}^{235}\text{O}_2$ -foil is  $(92 \pm 1)\%$ ; for a  $0.1 \text{ mg}/\text{cm}^2$  foil  $(97.5 \pm 0.3)\%$ . (auth)

16841

A METHOD OF LINEAR PULSE AMPLIFIER DESIGN. A. F. Fischmann-Arbel and Israel Bar-David (Ministry of Defence, Israel). *Nuclear Instr. & Methods* 7, 153-9(1960) May. (In English)

The root locus method of feedback amplifier analysis is applied in order to obtain maximum possible gain from a simple circuit configuration consistent with additional requirements of fast rise time, stable gain, monotonic step response, linearity, and fast recovery from overload. Coarse gain control may be realized by changing the feedback factor of such an amplifier; this eliminates distortions which may otherwise occur at low gain settings in the stage preceding the gain control and simultaneously increases the loop gain. Two practical design examples are given, with an over-all gain of 50,000 and 2,000, respectively. (auth)

16842

THIN FILM THICKNESS DISTRIBUTION BY ALPHA ABSORPTION. M. De Croës, W. Parker, and K. Sevier, Jr. (Inst. of Physics, Uppsala). *Nuclear Instr. & Methods* 7, 160-6(1960) May. (In English)

An instrument for the determination of thin film thickness distribution is described. Thickness distribution curves for films of organic compounds, metals, and aluminum oxide which are used primarily for counter windows and in connection with radioactive source preparation are presented. The principle employed, where the "gas-equivalent" of the film or foil of material is measured, provides results to a good degree of accuracy. (auth)

16843

A TRANSISTORIZED RING SCALER OF RESOLVING TIME 0.3  $\mu$ sec. G. W. Hutchinson, R. Rubinstein, and W. H. Wells (Univ. of Birmingham, Eng.). *Nuclear Instr. & Methods* 7, 167-73(1960) May. (In English)

A transistor decade counter is described, employing a ring principle, and capable of accepting pulses at a minimum separation of less than 0.3  $\mu$ sec. It includes a discriminator, pulse shaping circuit, and a gating circuit. Printed wiring is used throughout. (auth)

16844

A "TIME EXPANDER" FOR PRECISION NEUTRON TIME-OF-FLIGHT EXPERIMENTATION. J. R. Waters (Atomic Energy Research Establishment, Harwell, Berks, Eng.). *Nuclear Instr. & Methods* 7, 174-8(1960) May. (In English)

For accurate neutron time-of-flight experiments, narrow timing channels must be used. These are frequently generated by converting the time-of-flight of a neutron into a pulse of proportional amplitude and then performing a pulse height analysis. This converter, and also the one in the pulse height analyzer, are subject to drifting introducing inaccuracies into the measured data. The instrument described here replaces both of these converters with one entirely digital system which is inherently drift free. It uses a scaler to measure the number of fast "clock" pulses preceding the arrival of a neutron and then complements this number with slow pulses which are fed into the memory and display unit of the original spectrometer. Thus it allows a spectrometer designed for 2  $\mu$ sec timing channels to be used with 0.25  $\mu$ sec channels with no internal changes. Improved stability and reliability were obtained by the use of transistors throughout. (auth)

16845

APPLICATION OF BIDIRECTIONAL DEKATRON TUBES IN LOW LEVEL BETA ACTIVITY MEASUREMENTS BY CANCELLATION TECHNIQUE. K. S. Kuchela and L. H. Peshori (Atomic Energy Establishment, Trombay, India). *Nuclear Instr. & Methods* 7, 179-83(1960) May. (In English)

A new approach employing cancellation technique for reducing the background of a G-M counter (size: diameter =

2.5 cm, length = 5 cm) to less than 2 counts per minute was developed for the measurement of low level beta activity of the order of 25  $\mu$ c. The method and electronics used for cancellation are described. This method is a simple alternative to the usual anticoincidence shielding and needs only two G-M counters for determination of moderately low level beta activities. This technique was successfully applied for the study of the activity of biological samples from the sea. (auth)

16846

THE PROPANE BUBBLE CHAMBER USED WITH THE BIRMINGHAM PROTON SYNCHROTRON. J. D. Dowell, W. R. Frisken, G. Martelli, and B. Musgrave (The University, Birmingham, Eng.). *Nuclear Instr. & Methods* 7, 184-8(1960) May. (In English)

The design of a piston operated propane bubble chamber used in conjunction with the 1 Bev proton beam of the Birmingham synchrotron is described. The operating conditions and the method of analysis of photographs are discussed. (auth)

16847

A FAST LINEAR GATE CIRCUIT. F. P. G. Valckx and A. Dymans (Rijksuniversiteit, Utrecht). *Nuclear Instr. & Methods* 7, 197-200(1960) May. (In English)

An electronic gate circuit is described, which is linear for pulses up to 10 v over an impedance of 200  $\Omega$ . The gate-pulse width is determined by an external clipping cable and can be varied from 500 to 40 ns. The input can be of either polarity. The gate incorporates a fixed, well defined deadtime of about 50  $\mu$ s, which assures stable operation also at high counting rates. (auth)

16848

END-WINDOW PROPORTIONAL FLOW COUNTER TUBE. S. Forsén and J. Rydberg (Research Inst. of National Defense, Solna, Sweden). *Nuclear Instr. & Methods* 7, 204-6(1960) May. (In English)

A simple and reliable end-window proportional flow counter is described. The influence of anode wire loop position and size, gas mixture, and type of radiation source on the operation characteristics is given. (auth)

16849

PULSE ANALYSES IN STATISTICAL CONDITIONS. F. Sicard (Centre d'Etudes Nucléaires, Saclay, France). *Nuclear Instr. & Methods* 7, 207-9(1960) May. (In French)

Experiments were conducted with pulses having a statistical time distribution. A commutation over several channels is studied. The counting loss and the efficiency of each channel are calculated in the case of a Poisson distribution. (auth)

16850

BUBBLE DENSITY MEASURING DEVICE IN A DIETHYL ETHER BUBBLE CHAMBER. G. Kesseler and Ch. Schlier (Universität, Bonn). *Nuclear Instr. & Methods* 7, 210-12(1960) May. (In German)

The bubble density of minimum ionizing electron tracks is measured in a diethyl ether bubble chamber over a wide range of temperatures and pressures in the liquid. Some results can be compared with theory. (auth)

16851

AN ANTI-COINCIDENCE CIRCUIT FOR RANDOMLY DELAYED PULSES. S. Rozenstein (Ministry of Defence, Tel Aviv, Israel). *Nuclear Instr. & Methods* 7, 213-14(1960) May. (In English)

An anti-coincidence circuit is described consisting of a bistable multivibrator, a delay line, and a primed univ-

brator. Operation is actuated by the leading edges of the incoming pulses. The over-all dead time of the system is not affected by this anti-coincidence circuit. (auth)

16852

A CONVENIENT METHOD OF CONSTRUCTING ACCELERATOR SECTIONS. K. R. Chapman and S. Gowariker (Univ. of Birmingham, Eng.). Nuclear Instr. & Methods 7, 215-16(1960) May. (In English)

A method for the construction of focusing and accelerator sections for use with ion sources is described. The advantages of this method are stated and details given of the performance. A possible extension of the application of this technique is described. (auth)

16853

LOSS OF ACTIVITY FROM BETATRON IRRADIATED SAMPLES BY DIFFUSION. H. Fuchs and K. H. Lindenberger (Universität, Heidelberg, Ger.). Nuclear Instr. & Methods 7, 219-20(1960) May. (In English)

Relative integrated cross sections were established for photonuclear reactions leading to positron emitters. The ratios of residual activities were measured by counting the number of annihilation quanta. Several carbonaceous materials of varying thicknesses were irradiated with 34-Mev bremsstrahlung together with a reference sample of graphite. The C<sup>11</sup> activities resulting from C<sup>12</sup>( $\gamma$ ,n) processes were compared. The half life for each irradiation was established. The results are tabulated. (B.O.G.)

16854

HEALTH PHYSICS INSTRUMENTATION. [PART] 3. Denis Taylor (Plessey Nucleonics Ltd., Northampton, Eng.). Nuclear Power 5, No. 50, 110-14(1960) June.

A review of contamination monitors is given, in which several kinds of monitors are treated: combination (Geiger and beta window) for  $\beta$ - $\gamma$  counting, scintillation (ZnS-Ag for  $\alpha$ - $\beta$  counting, NaI(Tl) for  $\gamma$ ), special purpose (hands and clothing monitor), and monitors specific for a radioisotope (these for Pu<sup>239</sup>, U<sup>235</sup>, Cs<sup>137</sup>, and I<sup>131</sup> have been developed). Other topics treated are modification of monitors for smear tests, electronic circuits (cold-cathode tubes and transistors), scales, and measurement of low levels of radioactivity. (D.L.C.)

16855

A NEUTRON ABSORPTIOMETER FOR THE ON-STREAM ANALYSIS OF BORON. Carroll L. Pleasance (General Electric Co., Richland, Wash.). Trend. Eng. Univ. Wash. 12, No. 2, 2-3; 31-2(1960) Apr.

A prototype on-stream analyzer was developed for the analysis of boron added to solutions of U<sup>235</sup> for criticality control in the reprocessing of reactor fuels. The method used is determination of thermal neutron absorption. The analyzer, or neutron absorptiometer, is a neutron source surrounding a unit in which the solution being analyzed flows around a BF<sub>3</sub> counter at rates more than 50 gal/min. In order to slow the neutrons down to thermal energy, a paraffin moderator is used in conjunction with the source. Calibration curves are given for water and 60% HNO<sub>3</sub>, and analysis for boron can be carried out in the range of 0 to 2 g/l. The instrumentation necessary for recording the counting rate is described. (D.L.C.)

16856

A MODIFIED ION SLIT LENS FOR VIRTUAL VARIATION OF SLIT WIDTHS. A. J. H. Boerboom (F.O.M.-Laboratorium voor Massaspectrografie, Amsterdam). Z. Naturforsch. 15a, 350-5(1960) Apr. (In English)

It is shown that a slit lens system, already known in literature and used in mass spectrometer collector sys-

tems to vary the resolving power, can be greatly improved by introducing a potential on one of the electrodes, which previously was at zero potential. The focusing at the collector is unaltered within optical aberrations of the third order and the range of adjustment is increased as compared with the original system. Experimentally it was found that the virtual collector slit width could be adjusted from 1 mm down to 0.15 mm, maintaining a fair peak shape. (auth)

16857

THE PROPAGATION OF COUNTING-TUBE DISCHARGES IN COUNTING TUBES WITH ORGANIC VAPORS OR HALOGENS AS QUENCHER. W. Müller-Duysing, H. Neuert, and H. J. Stückenber (Universität, Hamburg). p.431-3 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In German)

The pulse form of Geiger counter discharges with organic vapors as quenching gas is studied with a fast oscilloscope and an RC which is small compared to the total pulse time. The electron component of the pulse shows a rectangular form with several smaller pulsations superposed. Time and length (number) of these additional pulsations, which depend from the percentage of quenching gas and voltage above threshold, seem to agree well with "burning length" and "burning time" of Wilkinson's theory on the tube counter discharge. Similar results are shown with halogen on counters (argon with iodine). (auth)

16858

RESONANCE PHOTONS IN GEIGER DISCHARGES.

P. Mortier, O. Segael, and J. Demuynck (Rijksuniversiteit, Ghent). p.434-7 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

In fast (rare gas-quenching vapor) counters the secondary mechanism is shown to depend on the photoionization of the quenching vapor by resonance photons of the rare gas, in the case the ionization potential of the vapor is lower than the resonance potential of the gas. The discharge is propagated smoothly; the velocity of propagation is rather small. In the opposite case secondary electrons are liberated from the cathode by soft photons. This discharge is propagated by large, irregular steps; the velocity of propagation is large. (auth)

16859

SOME PHENOMENA CONCERNING THE IGNITION OF GLOW-DISCHARGE TRIGGER TUBES. S. M. Frouws (N. V. Philips' Gloeilampenfabrieken, Eindhoven, Netherlands). p.438-42 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

In small cold cathode trigger tubes some interesting phenomena were observed. Two of those are mentioned and briefly discussed. The first concerns the influence of the floating potential of a metal film covering the inside of the insulating tube envelope, this coating being close to the main electrodes. Secondly, for a similar tube, the possibility of delivering quickly rising output pulses, which under certain conditions have a substantially higher amplitude than can be accounted for by a normal glow-discharge tube voltage drop. (auth)

16860

A DECADE INDICATOR GLOW-DISCHARGE TUBE OPERATING ON SIGNALS OF LOW CURRENT AND VOLTAGE. Th. P. J. Botden (Philips Research Labs., Eindhoven, Netherlands). p.443-7 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

An experimental tube is described which can be operated by signals of 3 to 5 volts and currents of 20 to 50  $\mu$ A. The signal is applied to one of the ten triggers; the main glow discharge is supplied by rectified a-c mains. The dependence of the required signal voltage on the electrode spacings, the gas composition, and the gas pressure are discussed. Results of measurements on the ignition and recovery times are given. (auth)

16861

ANOMALOUS ELECTRON EMISSION FROM COLD SURFACES IN THYRATRONS. R. J. Armstrong (Royal Radar Establishment, Malvern, Worcs, Eng.). p.448-55 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Very large current densities were observed to flow from cold electrodes in discharges which were initiated by, and are sustained by, hot cathode emission. The effects on this emission of geometry, potential differences, different gases, pressure, and surface conditions are considered. If the electrodes under investigation are placed at a distance of the order of a mean free path from the heated cathode, the form of the discharge and the current division between the electrodes depend markedly on the potential difference between the cold electrode and the cathode. The possible causes of the emission are discussed and the importance of the phenomenon in the practical operation of thyratrons and other devices is emphasized. (auth)

16862

COLD-CATHODE SWITCHING TUBE FOR LARGE CURRENTS. H. E. Seifert (Cerberus G.m.b.H., Männedorf, Switzerland). p.456-9 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In German)

Description of a new gas-filled cold-cathode tube for switching currents of several amps, requiring a supply voltage of 380 volts a-c or 530 volts d-c. In spite of its small dimensions the valve can easily switch 3 amps. Because no pre-heating is needed it has, during waiting periods, a power consumption of 0.1 watt only. Switching on is controlled by a pulse of about 100 volts and 30 sec. totalizing  $3 \times 10^{-7}$  watts/sec. (auth)

16863

CONTROLLING THE BREAKDOWN TIME OF A COLD-CATHODE ARC. R. Feinberg (College of Science and Tech., Manchester, Eng.). p.460-2 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Two commercially available cold-cathode arc conduction tetrodes having the same electrode geometry but different gas fillings were operated with rectangular-wave trigger pulses of positive polarity and variable duration, and it was found that the arc breakdown time of a valve depended on

the trigger pulse duration either alone or in combination with the pre-breakdown anode voltage of the valve. The mechanism of controllability of the arc breakdown time is explained in terms of the two modes of arc breakdown mechanisms which are effective in a valve as the result of the particular geometry of the electrode structure. (auth)

16864

THE MODES OF OPERATION OF A CASCADE SPARK GAP FOR PRECISION SWITCHING. R. A. Fitch and N. R. McCormick (Atomic Weapons Research Establishment, Aldermaston, Berks, Eng.). p.463-7 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The modes of operation of a 3-electrode triggered spark gap are discussed, in particular the 'swinging cascade mode' in which the first gap breaks down on a fast-rising pulse, and the second on the subsequent voltage overshoot across the stray capacitance of the common electrode. A theoretical analysis of this mode is described and compared with the experimental performance. Experiments show that under suitable conditions there is a continuous transition, as the working voltage is reduced, from the swinging cascade mode to a mode in which there is a simultaneous breakdown of both gaps, and under these conditions it is possible to obtain operation from the maximum working voltage down to zero volts. Measurements are given of the precision in firing of a pressurized 3-electrode gap. (auth)

16865

THE THREE ELECTRODE SPARK GAP AND ITS APPLICATION FOR THE SIMULTANEOUS SWITCHING OF MANY PARALLEL SPARK GAPS. Eduard Hintz and Hans Beermann (Technische Hochschule, Aachen). p.468-71 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The switching time and time jitter at the breakdown of open spark gaps fired by trigger sparks were measured as functions of electrode separation and voltage. The simultaneous switching of many parallel spark gaps on one load depends on electrical separation of the gaps during the mean jitter time and steep trigger pulses with short time jitter. A very low inductance condenser bank with 30 parallel switches was constructed on these principles. (auth)

16866

AN IMPROVED TECHNIQUE FOR THE MEASUREMENT OF VOLTAGE DROP AND ENERGY DISSIPATION IN TRIGATRONS. A. B. Hillan (Atomic Weapons Research Establishment, Aldermaston, Berks, Eng.). p.472-81 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

In past experimental work on the collapse of voltage across a spark gap switching a high power circuit, it has been the practice to correct for the inductive voltage drop by making a separate measurement of the voltage across a physically similar assembly in which a solid conductor is substituted for the spark channel and later manually subtracting this correction curve from that observed across the gap. This technique is tedious and usually inaccurate, particularly when the rate of rise of current in the circuit is  $10^9$  amperes per second or greater. A flux

cancellation technique is described in which the recording system automatically and accurately subtracts this inductive voltage component, thus giving a single record of the true voltage collapse across the spark gap. Some preliminary experiments using this technique are reported and from this work it is shown that the energy dissipated in a triggered three-electrode spark gap during the first rise of current in the circuit is of the form  $\epsilon = kIt^n$  where  $\epsilon$  is the energy dissipated up to the time  $t$ ,  $I$  is the current in the circuit at the time  $t$  and  $k$  and  $n$  are constants, the value of  $n$  being approximately one half. Finally, the experimental work is extended to cover the case of a square current discharge and it is shown that the above relations observed during the first rate of rise of current in the system applied to the case where the circuit current is constant. (auth)

16867

EXPERIMENTS AND INTERPRETATION ON CESIUM DIODES. J. Enoch and W. A. Ranken (Los Alamos Scientific Lab., N. Mex.). p.482-5 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The behavior of the cesium diode at low pressures is discussed theoretically on the basis of a simple model. An exact solution for the voltage and charge distribution based on the assumptions of the simple model is given and a more general case is discussed qualitatively. Predicted current-voltage characteristics are compared with experimental results. (auth)

16868

CESIUM PLASMA DIODE AS A HEAT-TO-ELECTRICAL-POWER TRANSDUCER. Wayne B. Nottingham (Massachusetts Inst. of Tech., Cambridge). p.486-501 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The new interest in the direct conversion of heat-to-electrical power has stimulated research in both the application of the high vacuum diode and the plasma diode to accomplish this purpose. The theory of the high vacuum diode is relatively simple and the experimental verification of the theory is satisfactory. The plasma diode which depends on the ionization of cesium at a hot surface cannot be worked out in all of its detail at present because of the lack of certain fundamental experimental data. It is possible to make use of published results of Taylor and Langmuir and a detailed analysis of recent thermionic studies to carry the understanding of the plasma diode far enough to make a direct comparison with experiment. This analysis first involves an understanding of the phenomenon of surface ionization. General properties of a plasma and space-charge considerations control the delivery of ions to neutralize electron space charge. When applied to the experimental data available, an interesting result comes as an important simplification. Essential to the theory of the high vacuum diode is the knowledge of the emitter temperature and the diode spacing. The electrical characteristics of the plasma diode have been found to be very closely duplicated by those of a high vacuum diode characterized by an effective distance that is reduced from the actual diode spacing. This fact supports the opinion that the efficiency of the plasma diode may be tremendously improved over that of vacuum diodes of practical design. (auth)

16869

DETERMINATION OF THE QUANTITY OF WATER VAPOR IN TR AND ATR TUBES BY ULTRAVIOLET SPECTROGRAPHY. R. P. Musson-Genon and E. Deschamps (Compagnie Française Thomson-Houston, Paris). p.511-14 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In French)

Partial water-vapor pressure in TR and ATR tubes during operation was determined. The study of an experimental spectrography method was made on tubes of the 1B27 type (S-band and external cavity). The intensity of the 3069 Å OH characteristic ray was observed as about proportional to partial water-vapor pressure. It is shown that the method is quite accurate and can be applied to standard TR and ATR tubes. (auth)

16870

THE SUDDEN DISCHARGE OF A CIRCULAR ENERGY STORAGE CONDENSER. Wolfgang G. Braun (Wright Air Development Center, Dayton, Ohio). p.523-7 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The mathematical analysis of the power transfer taking place in the central discharge of a circular disc condenser in the sense of a boundary value problem in electromagnetic theory is presented. The procedure used for the numerical computation of solutions is based on the method of characteristics. (auth)

16871

MAGNETIC FIELD PROBES WITH HIGH FREQUENCY RESPONSE. Karl Heinz Dippel and Wolfgang Teckenburg (Technische Hochschule, Aachen). p.533-6 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Magnetic field probes for application in fast transient magnetic fields were developed with a frequency response above 20 Mc/s and high sensitivity. Signals by capacitive stray fields are eliminated. The influence of probe geometry and the field distortion by the probes were measured in various media of different conductivity. The probes were used for measurements of conductivity, current density, and electric field strength in a high-frequency plasma. (auth)

16872

DETERMINATION OF THE DEIONIZATION TIMES OF DUPLEXER TUBES BY MEASURING THE LIGHT EMITTED BY THE DISCHARGE. J. Bricon and B. Fleury (Compagnie Française Thomson-Houston, Paris). p.537-40 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In French)

When the recovery time of a duplexer tube is known for a given filling pressure and magnetron power, it is possible to determine the recovery time of this tube for another pressure or magnetron power by the intensity of the light from the discharge after the end of magnetron pulses. This determination is however only possible within given limits of pressure and power. Measurement of recovery times by this method can favorably replace the microwave measurements for checking of tubes in manufacture and measurements at high powers. (auth)

## 16873

USE OF THE CORONA DISCHARGE FOR MEASUREMENTS OF TURBULENCE. B. Franzen and W. Fucks (Technische Hochschule, Aachen). p.549-51 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The response of the corona discharge to turbulent velocities is studied by comparing the output of a corona anemometer with that of a conventional hot-wire in a turbulent air flow. Spectral analysis of the signals shows, that the spatial resolution of the corona is of the order of the electrode spacing. The sensitivity is found to be independent of frequency up to at least 10 kc/s. A corona anemometer with an anode of 5  $\mu$  platinum wire is shown to be in good agreement with the hot-wire. A two-cathode-anemometer is described, by which down- and cross-stream components of turbulence can be measured simultaneously. (auth)

## 16874

A PLASMA PARAMETRIC AMPLIFIER. G. S. Kino and B. Ludovici (Stanford Univ., Calif.). p.762-7 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

A new type of parametric traveling-wave amplifier is described which makes use of the nonlinear properties of a gas-discharge plasma through which propagate electromagnetic waves. A theory which predicts the gain of this amplifier is given, the theory being based on taking second-order terms in the equations of motion into account. Early experimental results with such a device are given; it is shown that the parametric effects are present although the pumping powers required to obtain gain are an order of magnitude greater than is predicted by the theory. (auth)

## 16875

Denmark. Atomenergikommisionen. Forsøgsinstitut, Risø.

SIMULTANEOUS COUNTING OF ALPHA AND BETA RADIATION WITH ONE DETECTOR. Its Application for Measurement of Air Contamination. J. Lippert. p.79-83 of "Health Physics in Nuclear Installations Symposium, Risø, May 25-28, 1959." (In English)

Methods are given for counting alpha and beta particles simultaneously with one detector. The pulse spectra from a proportional counter are shown, which gives the relative pulse height distribution for  $\alpha$  and  $\beta$ . An arrangement is shown of an experimental continuous air monitor using two counters. The first counter indicates air contamination, while the second gives a more accurate measurement after all the radon daughters have disintegrated. (B.O.G.)

## 16876

Italy. Comitato Nazionale per le Ricerche Nucleari.

Centro Nazionale per le Ricerche Nucleari, Ispra.

A METHOD FOR SCINTILLATION COUNTING OF VERY-LOW-ENERGY PARTICLES. M. Forte and A. Anzani. p.193-200 of "Health Physics in Nuclear Installations Symposium, Risø, May 25-28, 1959." (In English)

A method is described which utilizes activated zinc sulfide in the scintillation counting of very low-energy particles. Its efficiency is such that the threshold of detection is below 1 kev, compared to 4 kev for previous methods. The circuit diagram of the multiplicity discriminator for this method is shown. The results from measurements of tritiated water of 1  $\mu$ c/cc specific activity are given. (B.O.G.)

## 16877

Uppsala Univ. Gustaf Werner Inst. for Nuclear Chemistry. THE APPLICATION OF A BIOLOGICAL DOSIMETER. H. B. Larsson. p.293-9 of "Health Physics in Nuclear Installations Symposium, Risø, May 25-28, 1959." (In English)

A method is described for estimating the radiation hazards from an external beam from a 200-Mev proton synchrocyclotron. A biological system was used to supplement the physical dose measurements. By scoring chromosome aberrations in the broad bean root, quantitative information was obtained on the effects of secondary radiation from different target materials. (B.O.G.)

## Materials Testing

## 16878 HW-39849

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

AN ULTRASONIC BOND TESTER FOR THE HANFORD CANNING LINE. D. C. Worlton. Nov. 7, 1955. Decl. June 10, 1960. 34p. OTS.

The ultrasonic tester and the frost test for insuring the metallurgical bonding of slugs are compared. The change from the triple dip to the lead dip method of canning caused more problems with the ultrasonic tester which is the more sensitive and consistent. Due to the high number of ultrasonic rejects and in view of the absence of pile performance data warranting a more costly approach, it has been decided that the ultrasonic rejects which pass the frost test will be considered safe for pile exposure. Circuits, photographs, data, and theory on the method are included. (M.H.R.)

## 16879 WADC-TR-59-762(Pt.I)

American Machine and Foundry Co., Alexandria, Va. ULTRA-SHORT-TIME CREEP RUPTURE EQUIPMENT MANUAL. [Period] covered: March 1, 1958 to March 31, 1959. Joseph S. Ives, Jr. Mar. 31, 1959. 51p. Project title: MATERIALS APPLICATIONS. Task title: EXPLORATORY DESIGN AND PROTOTYPE DEVELOPMENT. Contract AF33(616)-5557. OTS.

A program to develop a method of heating samples of sheet metal to a pre-determined temperature quickly and to measure the creep characteristics of this material at the developed temperature is described. Special equipments designed to carry out the work together with the necessary operating instructions are described. Also included are the drawings required to produce the equipment. (auth)

## GEOLOGY, MINERALOGY, AND METEOROLOGY

## 16880 ARF-3127-12

Illinois Inst. of Tech., Chicago. Armour Research Foundation.

PRELIMINARY STUDIES OF SCAVENGING SYSTEMS RELATED TO RADIOACTIVE FALLOUT. Summary Report

John Rosinski and J. Stockham. Apr. 29, 1960. 56p. ARF Project C 127. OTS.

A program consisting of two related phases is described. In Phase I, a study was made to find the relationship between the amount and nature of radioactivity, particle size distribution, and weight of particulate matter present in the lower troposphere. Emphasis was placed on the distribu-

tion of strontium-90 and total beta activity. Results of a limited number of analyses indicate that strontium-90 and total beta activity is associated primarily with particles below approximately 0.1 micron diameter. Phase II consisted of experimental studies on scavenging of solid particulate matter by water droplets. It was found that water vapor gradient around a condensing droplet promotes scavenging of particles of 1.3 micron and 0.3 micron diameters. The effect of water vapor gradient around an evaporating droplet is not well defined. (auth)

**16881** HW-57935

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

**THE SURFACE OF THE BASALT BEDROCK BENEATH THE HANFORD WORKS.** R. E. Brown and D. J. Brown. Nov. 13, 1958. 6p. Contract AT(45-1)-1350. OTS.

The topographic high and low features on the basalt surface beneath the Hanford Works are identified and named. (W.L.H.)

**16882** RME-105

Grand Junction Operations Office. Production Evaluation Div., AEC.

**EXPLORATORY DIAMOND DRILLING IN THE NO NAME CANYON AREA, WHITE CANYON DISTRICT, SAN JUAN COUNTY, UTAH.** Edward V. Mace and E. W. Oertell. Jan. 1958. 17p. OTS.

No Name Canyon is in the White Canyon district, approximately 86 miles west of Blanding, San Juan County, Utah. It is on the west flank of the Monument upward where exposed sedimentary rocks range in age from Permian to Jurassic. Uraninite associated with pyrite and carbonaceous material is localized within local basin-like scours on the northern flank of a southwest-trending paleostream channel at the base of the Shinarump member of the upper Triassic Chinle formation. An exploratory drilling program in 1954 consisted of 16 diamond-drill holes totaling 5,301 feet. Seven holes penetrated uranium deposits of subore grade; none encountered depcsits of ore grade. (auth)

**16883** SCR-183

Sandia Corp., Albuquerque, N. Mex.

**A SYSTEM OF STANDARD ATMOSPHERES.** B. N. Charles. May 1960. 35p. OTS.

A family of standard atmospheres is devised for defining vertical variations of temperature and pressure. These atmospheres approximate mean conditions over Eurasia, as deduced from limited climatological data. Data from North America, comprising over 57,000 observations, are compared with these atmosphere, and it is concluded that the temperature-height curves which are defined will approximate ambient conditions over the Northern Hemisphere at least 70% of the time. The degree of approximation is no greater than that to be inferred from the internal consistency of the defined family of standard atmospheres. Tables are presented showing the temperature, pressure, and density variations with altitude in each of 12 standard atmospheres. (auth)

**16884** TEI-762

Geological Survey, Washington, D. C.

**SUMMARY OF SOME PHYSICAL DATA FROM FIVE VERTICAL DRILL HOLES OVER THE U12b.04 (EVANS) EXPLOSION CHAMBER, NEVADA TEST SITE, NYE COUNTY, NEVADA.** Forrest G. Poole and John C. Roller. June 1959. 31p. OTS.

A summary is presented of the data obtained by petrographic analysis and determination of physical

properties of core samples of welded tuff of  $Tos_3$  on Rainier Mesa near ground zero. It represents interpretation of the sonic and other logs as related to the physical properties of the tuffs penetrated by the holes. The holes, assumed to be vertical, were 360 to 777 ft in depth and were bottomed 90 to 500 ft from the explosion chamber. (B.O.G.)

**16885** TEI-764

Geological Survey, Washington, D. C.

**SUPPLEMENTARY REPORT ON GEOLOGIC INVESTIGATIONS IN SUPPORT OF PHASE II, PROJECT CHARIOT IN THE VICINITY OF CAPE THOMPSON, NORTHWESTERN ALASKA.** Reuben Kachadoorian, A. H. Lachenbruch, G. W. Moore, and R. M. Waller. June 1960. 33p. OTS.

Since 1958 the U. S. Geological Survey, on behalf of the Atomic Energy Commission, has conducted geological studies to develop data which will contribute to determining the feasibility and safety of detonating several nuclear devices to create an excavation at the mouth of Ogotoruk Creek, northwestern Alaska. The proposed test excavation is Project Chariot of the Atomic Energy Commission's Operation Plowshare Program. The Geological Survey investigations in support of Project Chariot Phase II consisted of site geologic investigations, areal geologic mapping, coastal processes investigations, geothermal investigations, seismic velocity investigations, and water resources investigations. Seismic velocity investigations were in two categories; in-hole velocity and seismic refraction studies. Water resources investigations were in three categories; surface water, ground water, and quality of water studies. The preliminary results of the Survey's 1959 summer field work were reported in TEI-753. This supplementary report presents significant new geothermal and ground water information obtained during the winter and spring months of 1959 and 1960. Other Survey Phase II technical studies in progress have not yielded information that would materially affect the results reported in TEI-753. This report also contains observations and preliminary conclusions resulting from coastal processes studies in the field from May 3 to 9, 1960. A brief geologic summary also is included. (auth)

**16886** TID-5881

Columbia Univ., Palisades, N. Y. Lamont Geological Observatory.

**ISOTOPIC GEOCHEMISTRY OF URANIUM AND LEAD.** Project Renewal Proposal [covering period from] June 1, 1960 to May 31, 1961. J. Laurence Kulp. Apr. 15, 1960. 14p. Contract AT(30-1)-1114. OTS.

Research was devoted to the problem of the isotopic geochemistry of U and Pb in the Colorado plateau U ores, zircons of the basement of the Little Belt Mts., and ancient carbonate rocks. (W.L.H.)

**16887** TID-5966

Columbia Univ., Palisades, N. Y. Lamont Geological Observatory. Geochemical Lab.

**ISOTOPIC GEOCHEMISTRY OF URANIUM AND LEAD.** Annual Report for 1959-60. J. Laurence Kulp, Edward J. Catanzaro, Donald S. Miller, Ian Swainbank, and J. Marion Wampler. May 1, 1960. 211p. Contract AT(30-1)-1114. OTS.

An investigation of the isotopic relations of U, Pb, and S in the minerals of the Colorado Plateau uranium ores was made. The results indicate that the uranium mineralization probably occurred at more than one period of time, depending on the area and the host rock. The geologic occurrence of the Colorado Plateau uranium mineralization is described in general terms along with a short synopsis of

proposed origins. The lead loss hypothesis was found to account for the anomalies found in lead isotopic data. From studies on the isotopic geochemistry of the Swedish kholm, it was determined that the uranium was concentrated in the formation by direct precipitation from sea water under anaerobic conditions over 500 million years ago. In the Upper Cambrian Swedish kholm, the isotopic age discordance  $U^{238} - Pb^{208} < U^{235} - Pb^{207} < Pb^{207} - Pb^{206}$  was found to be present. Preferential removal of  $Pb^{206}$  is proposed to be an important cause of the discordance. Both radium and radon were found to be mobile in the kholm under suitable conditions. Techniques were developed for performing uranium and lead isotopic analysis of black shale surrounding the kholm. Studies on the lead isotope relations of the aguilar lead-zinc mine in Argentina suggested deposition in Triassic time from normal magmatic sources. The close association of the mineralization and faulting revealed that the faulting was pre-tertiary. A determination of a low lead content in marine carbonate shells supported the conclusion of Wedepohl that the lead in carbonate rocks is not, on the whole, directly co-precipitated with the carbonate. Age determination studies were performed on zircons from the Little Belt Mountains, Montana, and the Santa Catalina Mountains, Arizona. (C.J.G.)

**16888** AEC-tr-4098

A METHOD FOR CALCULATING THE MAGNITUDE OF THE GAMMA RADIATION AIR DOSE IN HOMOGENEOUS GEOLOGICAL MEDIA. R. M. Kogan. Translated from *Izvest. Akad. Nauk S.S.R., Ser. Geofiz.* No. 7, 988-94 (1959). 9p. JCL or LC.

This paper was previously abstracted from the original language and appears in *NSA*, Vol. 13, as abstract No. 20108. (W.L.H.)

**16889**

RADIOMETRIC ANALYSIS OF ORE ON CONVEYERS. L. N. Posik, S. I. Babichenko, and R. A. Grodko. *Atomnaya Energ.* 8, 425-31 (1960) May. (In Russian)

The principle, apparatus, and method for quantitative  $\gamma$ -analyses in conveyers are described. Results are given of radiometric analyses for various types of ore. (tr-auth)

**16890**

URANIUM PROSPECTION WITH THE HELICOPTER. Heinz Ziehr (Bayerische Braunkohlen-Industrie AG., Schwandorf, Ger.). *Atomwirtschaft* 5, 223-30 (1960) May. (In German)

In the spring of 1959 systematic prospection for uranium was made in Bavaria using an automatic recording scintillation detector carried by helicopter. The design and construction of the detection instrument are described. It is shown that, whereas the cost for the helicopter prospection is higher than that for automobile or airplane prospection, the higher costs are justified by better results. This method is valuable for the discovery of anomalies. The results of airborne prospection in Yugoslavia are briefly reviewed. (J.S.R.)

**16891**

URANIUM DEPOSITS OF THE SOUTHERN PART OF THE SAN JUAN BASIN, NEW MEXICO. Lowell S. Hilpert and Robert H. Moench (U. S. Geological Survey, Salt Lake City and U. S. Geological Survey, Denver). *Econ. Geol.* 55, 429-64 (1960) May.

Since 1950 about 50 million tons of uranium ore have been discovered along the southern margin of the San Juan Basin, New Mexico. Here the exposed sequence of sedimentary rocks ranges in age from Permian to Cretaceous, and is associated with intrusive and extrusive rocks of

Tertiary and Quaternary age. The uranium deposits are separable into three types—those in sandstones and associated mudstones of the Entrada and Morrison formations of Jurassic age, and Dakota sandstone of Cretaceous age; those in the Todilto limestone of Jurassic age; and one deposit in a pipelike structure in the Morrison formation. The deposits in the clastic sediments are similar to most of the uranium deposits in other parts of the Colorado Plateau region in type and habit of ore and accessory minerals, in the tabular form of ore bodies, and in their association with some form of carbonaceous material. The deposits in limestone have a somewhat similar mineral assemblage to that of the other deposits in the region but are unique in the type of host rock and their preference for structurally deformed beds. The pipelike deposit is unique. Although igneous activity has been intense in the eastern part of the area from late Tertiary to Recent time, there is no evidence to suggest a genetic relation between the igneous activity and the uranium deposits. In fact, what are probably the oldest exposed igneous rocks intrude and displace the deposits. Three periods of deformation are recognized. The first was during the time between the accumulation of the Entrada and Dakota sandstones, the second in the early to middle Tertiary, and the third in the middle to late Tertiary. Only structures of the first period show an obvious influence on the distribution and localization of the uranium deposits. From the pattern or frequency of distribution of the known deposits, and on the basis of interpretations from known geologic relations, the deposits seem to be clustered in a zone at least 20 miles wide north of the present outcrop. This zone is called the southern San Juan Basin mineral belt. Although the concept of this zone, or belt, restricts the favorable ground geographically, the amount of unexplored ground within the limits of the belt is enough to contain several times as much uranium resources as are now known. (auth)

**16892**

SULFUR ISOTOPE FRACTIONATION IN SULFIDE MINERALIZATION. S. Gavelin, A. Parwel, and R. Ryhage (Stockholms Högskola, Stockholm). *Econ. Geol.* 55, 510-30 (1960) May.

The isotopic compositions of sulfides and sulfates from various types of sulfide formations were determined. A description of the preparation of sulfurous minerals for mass-spectrometric analysis and of the mass-spectrometric procedure is given. The results agree in several respects with previous investigations. Various sulfides representing a continuous mineralization process display no significant divergencies if the early and the late minerals are compared. Nor does the material examined indicate any correlation between isotopic composition and zonal arrangement of minerals and metals around emanative centers, in cases where such zoning is evidenced by the regional geological features. A certain correlation between kind of wallrock and isotopic composition may be indicated. If considerable variations of isotopic compositions are found to exist in an ore district, the range of variation seems to be wider in the low-temperature than in the high-temperature sulfides. Supergene oxidation of sulfides to sulfate takes place without change in isotopic composition. A subsequent redeposition of supergene sulfides may involve a displacement of the isotope ratios towards lighter sulfur. Hypogene sulfide mineralization, where both sulfides and sulfates are formed, is apt to cause significant fractionation of the original isotopic composition of the participant sulfur. Local variations indicate that the process may develop differently over short distances. The

local character of some isotope exchange reactions is evidenced for instance by considerable variation in the isotope ratios even in a single hand specimen. The range of such variations is generally found to be wider in low-temperature than in high-temperature mineral assemblages. (auth)

## 16892

GEOLOGY, SULFUR ISOTOPES AND THE ORIGIN OF THE HEATH STEELE ORE DEPOSITS, NEWCASTLE, N. B., CANADA. E. Dechow (Yale Univ., New Haven). Econ. Geol. **55**, 539-56 (1960) May.

The Heath Steele mine is located 35 miles northwest of Newcastle, New Brunswick, Canada. Middle Ordovician Tetagouche Group rocks, consisting of siliceous and basic volcanic rocks, and fine-grained quartz sericite schists and porphyry, have been folded into a steeply plunging recumbent anticline. The ore deposits of zinc, lead, and copper are associated with minor folding and/or sheared dilatent zones at or near the contact between porphyry and fine-grained sericitic schist. Mineralogically the sulfide bodies consist of early, euhedral arsenopyrite, magnetite, and pyrite, followed by interstitial pyrrhotite, sphalerite, chalcopyrite and galena. Minor minerals are tennantite-tetrahedrite, bismuthinite, marcasite, hematite, and some graphite. Supergene minerals consist of chalcocite, covellite, and marcasite with a little native silver. Little hypogene replacement has taken place between the minerals, which show a "porphyritic" texture. Sulfur isotope ratios were determined for over 150 sulfide and sulfate specimens from five of the seven ore bodies, and from granite, acid and basic volcanics, porphyry, and sediments. The results indicate that there is no detectable fractionation either during hypogene mineralization or supergene enrichment. The spread (21.82 to 22.02) covered by the ratios is narrow, and suggestive of a well homogenized source of mineral solutions. The enrichment of  $S^{34}$  in the ore sulfides and the presence of graphite, evident from mineralographic studies and mass spectrometric analysis, suggests reduction of original sulfates (known to be enriched in  $S^{34}$ ) by organic carbon at temperatures in excess of 600°C. A calculation based on the isotopic exchange reaction between sulfide and sulfate under equilibrium conditions and the spread of the ratios indicates a temperature of 700 to 800°C for the source. Finally the ratios determined for sulfides in a gneissic granite close to Heath Steele have the same ratio as the ore. These factors are considered to be diagnostic of a magmatic hydrothermal origin for the ore deposits. It is believed that an original source bed has been buried until suitable temperatures were reached to cause granitization, reduction of sulfates, and mobilization of the resulting sulfides to form ore deposits at favorable loci. (auth)

## 16894

ISOTOPIC COMPOSITION OF LEAD AND PRECAMBRIAN MINERALIZATION OF THE COEUR D'ALENE DISTRICT, IDAHO. A. Long, A. J. Silverman, and J. L. Kulp (Columbia Univ., New York). Econ. Geol. **55**, 645-58 (1960) June-July.

Galena samples representing the vertical and geographical extent of the Coeur d'Alene mining district have been isotopically analyzed for lead. The isotopic composition is essentially uniform at  $Pb^{208}/Pb^{204} = 16.44$ ,  $Pb^{207}/Pb^{204} = 15.58$ ,  $Pb^{206}/Pb^{204} = 36.52$ . The common lead age from this average is about 1,400 million years. This is consistent with other isotope data in the district and may be considered the time of primary mineralization. The original Belt Series and its metamorphic equivalents are, therefore,

older than 1,400 m.y. Precambrian lead in veinlets cutting Laramide monzonite dikes and stocks present positive evidence for sulfide remobilization in Tertiary time in the vicinity of these igneous intrusions. Some minor rock lead was also introduced as galena during this event. (auth)

## 16895

ON THE BLIND RIVER URANIUM ORES AND THEIR ORIGIN. D. S. Robertson and N. C. Steenland (GMX Corp., Toronto). Econ. Geol. **55**, 659-94 (1960) June-July.

Ore conglomerates of the Blind River area lie at or near the base of the Huronian sedimentary section in discontinuous, sheet-like, partly overlapping, south east trending zones within a major north northeast belt. They are part of a sequence of detrital sediments laid down in a beach and delta environment by a northward transgressing sea. The Huronian rocks are cut by basic dikes and by quartz veins, both of which have been dated. The ore conglomerates are older than 1,200 m.y. and probably older than 1,700 m.y. The uranium minerals, brannerite, uraninite and a "monazite" complex, occur with a typical detrital assemblage and appear themselves to be detrital. The ore minerals are considered to be syngenetic and of the age of the conglomerates. Age determinations on the ores suggest that the radioactive minerals have been modified, or that material has been introduced, at 1,300 m.y. and at 600 m.y. Differences between the Witwatersrand and Blind River are discussed briefly. (auth)

## 16896

EXPLORATION OF UNDERGROUND WATER MOVEMENTS WITH RADIOISOTOPES. László Bozóky and Dániel Vödrös. Energia es Atomtech. **13**, 135-6 (1960) Mar. (In Hungarian)

A device for injecting isotopic tracer solutions for underground water studies is described. It consists of three interconnected compartments of 0.5 to 1.0 liter each. The top and bottom compartments contain water, the center one holds the tracer solution. The bottom compartment is attached to a steel pipe of desired length perforated at its bottom end. Compressed air empties the compartments in succession into the perforated pipe. The advantage of this system is that the entire tracer solution can be injected into the underground stream simultaneously, thereby cutting the total observation time. (JPRS)

## 16897

RADIOCHEMICAL ANALYSES OF FISSION DEBRIS IN THE AIR ALONG THE 80th MERIDIAN, WEST. L. B. Lockhart, Jr., R. A. Baus, R. L. Patterson, Jr., and A. W. Saunders, Jr. (U. S. Naval Research Lab., Washington, D. C.). J. Geophys. Research **65**, 1711-22 (1960) June.

A number of radioisotopes formed in high yield by nuclear explosions were determined quantitatively in the gross-fission-product conglomerate collected by air filters at sites along the 80th meridian during the IGY. Radiochemical analyses show that debris from two (or more) nuclear tests of the U. S. Hardtack Series in the Pacific crossed the equator. Save for the period of gross contamination in the troposphere by Hardtack debris, the average age of the fission-product conglomerate in the air was consistently older in the southern than in the northern hemisphere. The  $Sr^{89}$  content of the air has shown a general pattern of maxima in the region between 20° and 40°N and S latitudes and a minimum in the equatorial region. During early 1958 the maximum in the north averaged about 7 times that in the south. The rapid spread of radioactivity from the Hardtack tests (identified by the presence of  $W^{186}$ )

and from Soviet nuclear tests emphasizes the fact that debris is not restricted to a narrow zone near the latitude of introduction. (auth)

16898

USE OF A SPECIAL APPARATUS FOR RAPID ANALYSIS OF WORKED ORE BY MEANS OF  $\gamma$  RADIATION. L. N. Posik and I. M. Tenenbaum. Kernenergie 1, 294-300(1958) Apr. (In German)

For direct determination of the quantity and quality of worked ore and commercial ore in carts or trucks or for separation of worked rock, waste, and mine filling from U ore, the type RKS installation (continuous control radiometer) is used. Characteristics of this instrument setup are given, and the mining conditions for its use are described as well as the problems which with its use can be solved. From the standpoint of utility of the RKS-1 and RKS-2 installations for direct calculation of the yield of a location, calculation of ore mixtures, or the preventing of metal losses or ore deterioration, the ore mines can be divided into two groups: those for raw ore production and those with selective ore production. The RKS-2 is useful in the former and the RKS-1 in the latter. These determinations form the basis for yield analyses in hydrothermal veins with slightly thick but rich ore inclusions. Rapid analyses of rich mine filling can be made with the RKS-1. The RKS-2 not only determines the activity of the ore and rocks directly while work proceeds but prevents power losses in hauling, sorting, and unloading of carts with worked ore with complete automation. (tr-auth)

16899

GAMMA ABSORPTION CAN MEASURE BARITE CONTENT. Charles L. Hill and Murray F. Hawkins (Louisiana State Univ., Baton Rouge) and Richard L. Caldwell (Socony Mobil Oil Co., Dallas). Nucleonics 18, No. 6, 130; 132-3(1960) June.

A method for the determination of barite content in oil-well drilling mud was developed and consists of measuring barite's absorption of weak gamma photons (84 kev) from  $Tm^{170}$ . For barite contents up to 1 lb/gal, an absorption path of 5 cm is used; for contents of 1 to 12 lb/gal, 2 cm is used. A 10% interchange in clay and water concentrations introduces only a 0.26% error in the indicated barite content. Either a G-M counter or a scintillation detector can be used, although the latter gives more linearity to the calibration curve. (D.L.C.)

16900

$\gamma$ -RAY SPECTROSCOPY OF ARTIFICIAL RADIOACTIVE SAMPLES FROM ATMOSPHERIC AIR. F. Demichelis (Istituto di Fisica Sperimentale del Politecnico, Turin) and G. Lovera (Università, Modena, Italy). Nuovo cimento (10) 15, 970-78(1960) Mar. 16. (In English)

Eight air samples were collected in Naples between October 1958 and June 1959 by filtration on paper and analyzed for their gamma radiation. The radiation was analyzed in the range of energies 0.25 to 1.70 Mev; in addition, sample No. 8 was analyzed in the range 0.03 to 0.70 Mev. Samples No. 8 and 7 are considered in detail. The 0.36 Mev peak (due to  $I^{131}$ ,  $Ba^{146}$ , and  $La^{146}$ ) decayed more rapidly than the others. Corrections for the Compton background were calculated with the 0.75 Mev peak due to  $Zr^{95}$  and  $Nb^{95}$  as reference. Use is made of the data to locate the date of the event producing the radioactivity, and it is concluded that the jet stream passing over Naples could have contributed to the radioactivity of sample No. 8. (D.L.C.)

## HEALTH AND SAFETY

16901 NAA-SR-Memo-2055

Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.

SPECTROGRAPHIC MONITORING FOR AIRBORNE BeO. Stanley B. Austerman and Frances Farrah. [1957]. 13p. OTS.

The equipment and methods used to analyze monitor samples of BeO are described. Analysis of between 0.01 and 20  $\mu$ g Be can be performed, allowing detection of either very low concentrations of Be or rapid release of large quantities. (auth)

16902 WT-1498

Food and Drug Administration, Washington, D. C. and Office of Civil and Defense Mobilization, Battle Creek, Mich.

MEASURING AND MONITORING TRAINING EXERCISE: FOODSTUFFS. Homer J. McConnell, Raymond D. Chapman, Alan T. Spiller, Edwin P. Laug, Stephen E. Koelz, and Harold V. Leininger. Dec. 1959. 25p. Project 38.3 [of] OPERATION PLUMBOB. OTS.

A field-training course was conducted in areas contaminated by radioactive fall-out. Information was acquired on methods of measuring and monitoring fall-out with portable and laboratory equipment and on methods of decontamination from study and actual participation in the shots of Operation Plumbbob from April 29 through June 29. Participation consisted in dry runs and actual runs under shot conditions. There were two types of runs. One consisted in the placement under fall-out and later pick-up of fall-out collecting stations and recording devices. The other consisted in the placement under fall-out and later collection of foodstuffs. Each operation was followed by laboratory determinations of the amount of fall-out contamination. Decontamination of the fall-out collecting stations was carried out to recover all the fall-out material possible for further study. Decontamination of foodstuffs was carried out to test the feasibility of such types of operation only. (auth)

16903 AEC-tr-3656(p.246-63)

PRINCIPLES OF CALCULATION OF MAXIMUM PERMISSIBLE LEVELS OF EXTERNAL BEAMS OF IONIZING RADIATION. N. G. Gusev. p.246-63 of "Research in the Field of Dosimetry of Ionizing Radiation." K. K. Aglintsev, ed.

Problems involved in establishing maximum permissible levels of ionizing radiation are discussed. Data are reviewed on which present levels of permissible radiation for man are based. (C.H.)

16904 JPRS-2592(p.108-11)

THE PROBLEM OF SANITATION AND HYGIENE MEASURES IN THE ATOMIC ICEBREAKER "LENIN." A. I. Burnazyan, I. D. Kamyshenko, and Yu. G. Nefedov. Translated from Med. Radiol. 4, No. 4, 70-2(1959). 4p.

This paper was previously abstracted from the original language and appears in NSA, Vol. 13, as abstract No. 16139.

16905

THE QUESTION OF USE OF THE BIOLOGICAL DOSE UNIT "REM" IN RADIATION PROTECTION. RELATIVE BIOLOGICAL EFFECTIVENESS OF DIFFERENT RADIATIONS IN MAMMALS. U. Hagen and H. Langendorff (Universität, Freiburg i. B. and Heiligenberg-Instituts, Heiligenberg/Baden, Ger.). Atomkernenergie 5, 173-81 (1960) May. (In German)

The dosage value "rem" is dependent on two values: on the dosage of a certain type of radiation which can be physically measured in "rad," and on the relative biological effect (RBE) of this radiation as compared to radium,  $\gamma$ -rays, or X-rays. In order to have a safe basis for legislation concerning protection against radiation, the RBE of radiation must be clearly defined in addition to the physical dose. Such a schematic determination of the RBE in the regulations is only possible with reservations. Based on extensive experimental studies on the RBE in mammals, it is shown that the RBE of the various symptoms of the radiation disease increases with increasing specific ionization of radiation but decreases in radiations with very high specific ionization. A number of other factors also determine the RBE of a specific radiation symptom. In acute irradiation, RBE values above 5 have not been measured recently. Possibly, the RBE of various radiations is much greater in chronic irradiation; however, the statistics at hand are not sufficient as yet to make any commitments. (auth)

## 16906

ACTIVATED ISOTOPE PACKAGES. L. v. Erichsen and W. Borger (Universität, Bonn). Atomkernenergie 5, 181-2 (1960) May. (In German)

A radioactivity detected in Al isotope shipping containers was identified as  $\text{Fe}^{55}$  and  $\text{Zn}^{65}$ . The process of separating the  $\text{Fe}^{55}$  and  $\text{Zn}^{65}$  from Al is described. (T.R.H.)

## 16907

EXPERIENCE IN THE HANDLING OF SEALED GAMMA-ACTIVE ISOTOPES. Jozsef Hirling (Csepel Iron and Steel Works, Hungary). Energia es Atomtech. 13, 82-5 (1960) Jan.-Feb. (In Hungarian)

Transport casks for sealed gamma-active isotopes and laboratory equipment (portable lead shields, two types of remote handling rods) used to unpack the isotopes and to place them into capsules are described. For its own use and for other institutes as well, the Csepel Iron and Steel Works in 1959 prepared 180 capsules of Soviet gamma-active isotopes, the equivalent of about 1.0 kg of Ra. The personnel assigned to this work was exposed to only 23 to 37% of the maximum permissible exposure. (JPRS)

## 16908

AN INVESTIGATION ON SIMPLE ORDER-OF-MAGNITUDE ESTIMATION OF THE DOSE POWER OF  $\beta$  RADIATION IN A TISSUE SURFACE LAYER. Michael v. Rimscha (Staatliche Ingenieurschule, Kiel). Kerntechnik 2, 166-7 (1960) May. (In German)

A formula for the rough estimation of the  $\beta$  dose at the tissue surface was derived with the following simplifying assumptions: disappearing self-absorption in the radiator, disappearing absorption in the air between radiator and object, neglect of the back-scattering at the tissue surface, and neglect of the conversion of the penetrating  $\beta$  radiation into  $\gamma$  radiation. (J.S.R.)

## 16909

BERYLLIUM HANDLING AT LUCAS HEIGHTS. G. L. Hanna, K. D. Reeve, and W. J. Wright (Australian Atomic Energy Commission, Lucas Heights). Nuclear Eng. 5, 258-60 (1960) June.

The design of the Australian AEC's temporary beryllium laboratory at Lucas Heights for maximum safety is outlined. The USAEC recommendations for maximum permissible concentrations of Be in air were adapted, 2  $\mu\text{g}/\text{m}^3$  as mean over an 8-hr day, 25  $\mu\text{g}/\text{m}^3$  at any one time, and 0.01  $\mu\text{g}/\text{m}^3$  in the neighborhood of the plant, and a surface contamination tolerance level of 1  $\mu\text{g}/\text{ft}^2$  was set. Ventila-

tion of at least 10 air changes per hour is provided in the laboratory, handling of Be is carried out in glove boxes, and fabrication of Be is done in ventilated boxes with glove ports. Changing procedures and laboratory hygiene are described. A table of the criteria for the laboratory design is given. (D.L.C.)

## 16910

European Nuclear Energy Agency, Paris and Denmark. Atomenergikommisionen, Copenhagen.

HEALTH PHYSICS IN NUCLEAR INSTALLATIONS SYMPOSIUM, RISØ, MAY 25-28, 1959. 1959. 414p. (In English and French)

The proceedings of the Symposium held at Risø in May 1959 are presented. The presentations were concerned with fundamental scientific principles, measurement and control of radiation and contamination in working areas, control of personnel contamination, practical problems in specific types of installations, measurement techniques and shielding problems in relation to high-energy accelerators, and emergency situations. Thirty-one papers are included; separate abstracts have been prepared for 25. Six papers were previously abstracted in NSA. The papers presented by personnel from the United States may be found in TID-7577. (B.O.G.)

## 16911

United Kingdom Atomic Energy Authority. Weapons Group. Atomic Weapons Research Establishment, Aldermaston, Berks, England.

BASIC CRITERIA IN THE CONTROL OF AIR AND SURFACE CONTAMINATION. D. E. Barnes. p.47-52 of "Health Physics in Nuclear Installations Symposium, Risø, May 25-28, 1959." (In English)

Permissible doses for persons exposed to radiation have been internationally agreed upon by the ICRP. The methods used in deriving the permissible concentrations in air have been published by the ICRP. The surfaces considered in these derivations were laboratory surfaces, skin, objects to be taken from controlled areas, and objects located outside the controlled area. It is emphasized that the tabulated values are those which seem to be reasonable. (B.O.G.)

## 16912

France. Commissariat à l'Énergie Atomique. Centre d'Etudes Nucléaires, Saclay.

TECHNIQUE FOR MEASURING AIR CONTAMINATION. J. Labeyrie. p.53-66 of "Health Physics in Nuclear Installations Symposium, Risø, May 25-28, 1959." (In French)

Techniques are reviewed for measuring local radioactive contamination around mines, laboratories, and nuclear installations, and general radioactive contamination. General contamination includes  $\text{C}^{14}$ ,  $\text{T}$ , other natural light isotopes such as  $\text{Be}^7$ ,  $\text{Be}^{10}$ ,  $\text{Na}^{22}$ ,  $\text{P}^{32}$ ,  $\text{S}^{35}$ , and  $\text{Cl}^{36}$ , radon and its derivatives, fission products from atomic explosions, and  $\text{Kr}^{85}$ . Local contamination methods deal with aerosols and radioactive gases. Tabulations are included on measurement techniques for aerosols and radioactive gases, maximum permissible concentration, and general contamination values at Saclay (1958), and  $\text{T}$  concentration in rain. (T.R.H.)

## 16913

France. Commissariat à l'Énergie Atomique. Centre d'Etudes Nucléaires, Saclay.

DEVELOPMENT OF STANDARDIZED EQUIPMENT ESPECIALLY ADAPTED TO DIFFERENT METHODS OF RADIATION CONTROL. J. Savouyaud and A. Menoux. p.67-77 of "Health Physics in Nuclear Installations Symposium, Risø, May 25-28, 1959." (In French)

The need for standardized health physics equipment thus far developed is described. For contamination control of surfaces, liquids, and aerosols the various instruments are discussed. The instruments for irradiation control are then discussed. (T.R.H.)

## 16914

France. Commissariat à l'Énergie Atomique. Centre d'Etudes Nucléaires, Saclay.

IMPROVEMENTS IN INDIVIDUAL DOSIMETRY BY EMULSION PHOTOGRAPHY. G. Soudain. p.85-91 of "Health Physics in Nuclear Installations Symposium, Risø, May 25-28, 1959." (In French)

A personnel dosimetry device with 3 emulsions arranged to give a range of 10 mr to 800 r is described. Doses can be approximated to 20% by comparison with a standard gray-scale. (T.R.H.)

## 16915

United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England.

THE APPLICATION OF GAMMA-RAY SPECTROMETRY IN HEALTH PHYSICS (OTHER THAN FOR BODY MONITORING). D. H. Peirson. p.147-56 of "Health Physics in Nuclear Installations Symposium, Risø, May 25-28, 1959." (In English)

Adaptations of the  $\gamma$  spectrometer to health physics are reviewed. Techniques are demonstrated by examples from occupational contamination, nuclear weapons debris, and from environmental surveys. Analysis by this means avoids and supplements chemical processing and may be made on the samples directly. Correction for self-absorption is usually unnecessary. (B.O.G.)

## 16916

France. Commissariat à l'Énergie Atomique. Centre d'Etudes Nucléaires, Saclay.

EXPERIENCE IN GAMMA SPECTROMETRY. L. Jeanmaire. p.157-65 of "Health Physics in Nuclear Installations Symposium, Risø, May 25-28, 1959." (In French)

Use of a gamma spectrometer in measuring contamination of a human being is described. An NaI crystal 20 cm in diam  $\times$  10 cm long was used with a 25-channel SAE 25 selector, and 5-cm lead shielding. Curves of gamma energy versus time are given for natural radioactivity,  $I^{131}$  contamination,  $Co^{60}$  contamination, mixed  $I^{131}$  and  $Co^{60}$ , gross activity, powdered milk, and a man irradiated with neutrons. (T.R.H.)

## 16917

Atomic Energy of Canada Ltd., Chalk River, Ont.

PROGRESS AND EXPERIENCE IN DECONTAMINATION TECHNIQUES. J. Neil. p.225-36 of "Health Physics in Nuclear Installations Symposium, Risø, May 25-28, 1959." (In English)

Decontamination techniques at the main plant of Atomic Energy of Canada Ltd. are discussed. At present the decontamination of protective clothing and equipment is largely performed automatically, whereas this was done by hand by personnel in the immediate area of contamination in 1945. When the NRX went out of control, it was found that the processes in use were extremely time-consuming, and there was a lack of man-power and space. To speed up the cleaning of protective clothing, a commercial washing machine was used. A metal parts washer was installed to cleanse the dismantled equipment. The capacity of this washer was 350 kg and was fully automatic after the loading operation. The methods used at Chalk River have not changed much since the incident of 1952 and usually con-

sist of vacuum-cleaning, steam-cleaning followed by hand cleaning, roto-grinding concrete floors, sand blasting, and flame priming followed by wire brushing. (B.O.G.)

## 16918

United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England.

ORGANISATIONAL AND RADIOLOGICAL PROBLEMS IN THE CONTROL OF CRITICALITY. C. M. Nicholls and B. A. J. Lister. p.253-9 of "Health Physics in Nuclear Installations Symposium, Risø, May 25-28, 1959." (In English)

Ways are suggested in which organization and fore-thought might prevent accidental critical excursions, point out problems which exist in planning to minimize harm in the case of an accident, and assess the consequences. (B.O.G.)

## 16919

Oak Ridge [National Lab.], Tenn.

SOME PROBLEMS IN THE CONTROL OF CRITICALITY. Karl Z. Morgan. p.261-8 of "Health Physics in Nuclear Installations Symposium, Risø, May 25-28, 1959." (In English)

The administrative and design control areas in criticality control problems are discussed with reference to the Y-12 incident in 1958. One of the situations considered most likely to lead to difficult criticality control is that in which areas under design control meet or overlap areas under administrative control. Emphasis is placed on the importance of criticality measurements and calculations because of the small number of accidents which furnish useful guidance. (B.O.G.)

## 16920

France. Commissariat à l'Énergie Atomique. Centre d'Etudes Nucléaires, Saclay.

HOW TO ESTABLISH PRACTICAL RULES TO AVOID CONTAMINATION. F. Duhamel and J. M. Lavie. p.317-36 of "Health Physics in Nuclear Installations Symposium, Risø, May 25-28, 1959." (In French)

Starting with biological data furnished by the International Commission on Radiation Protection and some physical or practical considerations, a method is demonstrated for selecting a coherent and continuous hazard classification of radioelements. Such a classification facilitates the establishment of detailed regulations adaptable to the complex situation of contamination by inhalation. These regulations will not interfere with special regulations such as those for fissionable material. The data can be changed without changing the method, but the regulation would have to undergo an adaptation. (T.R.H.)

## 16921

France. Commissariat à l'Énergie Atomique. Centre d'Etudes Nucléaires, Saclay.

EMERGENCY MEASURES AND TREATMENT IN CASE OF ACCIDENTAL OVEREXPOSURE TO RADIATION OR IN CASE OF RADIOACTIVE CONTAMINATION. H. Jammet. p.385-94 of "Health Physics in Nuclear Installations Symposium, Risø, May 25-28, 1959." (In French)

Emergency treatment for radiation overexposure and for radioactive contamination is discussed for doctors. The discussion covers the cases of internal contamination, external contamination, acute partial irradiation, and acute total irradiation. Considerations in the choice of therapy for accidental irradiation below 400 to 500 rem, for 400 to 1000 rem, and for over 800 rem are given. (T.R.H.)

**16922**

Kernreaktor Bau- und Betriebs-Gesellschaft m.b.H. Institut für Strahlenbiologie, Karlsruhe, Germany. RECENT DEVELOPMENTS IN INTERNAL DECONTAMINATION METHODS. A. Catsch. p.379-84 of "Health Physics in Nuclear Installations Symposium, Risø, May 25-28, 1959." (In English)

A summary of experimental results is presented comparing the effectiveness of ethylenediaminetetraacetic acid (EDTA) and diethylenetriaminepentaacetic acid (DTPA) as internal decontamination compounds. These results produce evidence that it is more advantageous to use DTPA. (B.O.G.)

**16923**

United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England.

SOME LESSONS FROM THE WINDSCALE ACCIDENT. B. S. Smith. p.395-401 of "Health Physics in Nuclear Installations Symposium, Risø, May 25-28, 1959." (In English)

Three aspects of the Windscale accident are discussed: (1) comparison of the deposition of iodine with the forecast deposition from a reactor accident, (2) effect of stack height in reducing the close-in exposure, and (3) deposited iodine activity as a guide to milk activity. Curves are given for deposition of  $I^{131}$  compared to theoretical maximum and axial concentration at ground level. (B.O.G.)

## INDUSTRIAL APPLICATIONS OF ISOTOPES AND RADIATIONS

**16924 MND-R-1966**

Martin Co. Nuclear Div., Baltimore.

RESEARCH AND DEVELOPMENT OF RADIOISOTOPE HEATER. Quarterly Progress Report No. 2 [for] July 16 to October 15, 1959. 32p. Contract AF33(616)-6325. (AD-228202).

A successful test was conducted in which the desired operating temperature ( $700 \pm 25^\circ\text{C}$ ) on a cathode was attained with an electrical heater. Designs for two temperature-controlling devices were completed. An analysis of these designs demonstrated that it is possible to maintain a constant temperature on the cathode for 5000 hrs with  $\text{Po}^{210}$  as a heat source. (For preceding period see MND-R-1965.) (C.J.G.)

**16925 NYO-2500(COND.)**

Radiation Applications Inc., New York.

THE TECHNOLOGY AND APPLICATIONS OF LARGE FUSION PRODUCT BETA SOURCES. [1959?]. 38p. OTS.

An analysis of radiation processing shows promising areas for commercial application of large quantities of fission product beta emitters which include graft copolymerization modification of formed plastic surfaces, vapor phase synthesis of organic compounds, and sterilization of surgical and medical supplies. Chain reaction processes that provide greater product yield per unit dose at lower dose rates (such as grafting on textile or plastic films) offer particular promise. The surface modification of textiles and of plastic film or sheet is particularly suited to the use of betas because the penetration requirements are low, and beta particles give low penetrations and expend the whole of their ionizing energies within absorber thicknesses that are of particular interest for such applications. A large number of desirable surface modifications were

effected by the use of radiation-induced reactions. Among these are increased tensile strength, elastic modulus, printability, dyeability, and wettability of polyethylene; increased heat sealability and adhesive acceptability of teflon; and increased electrical conductivity and dyeability of other plastics and textile fibers. Massive, rugged, inert, safe, inexpensive beta sources may be fabricated by suitable extensions of existing techniques. Thin source-bearing glass coatings on solid, thin sheet, or wire mesh backings show particular promise. Beta power absorption calculations indicate that extended beta sources of a practical design may be used with reasonably good efficiency of beta power utilization. An engineering cost analysis indicates that fission product beta power can be competitive with alternative sources of radiation. (auth)

**16926 TID-5969**

Chicago. Univ. Chicago Midway Labs.

THE APPLICATIONS OF ISOTOPES TO INDUSTRIAL PROBLEMS. Progress Report No. 14 for April 16 to May 16, 1960. Foster F. Rieke. May 20, 1960. 17p. Contract AT(11-1)-712. (LAS-L-P161-14). OTS.

Wear and lubrication studies on piston rings were continued using iron-59 and cobalt-60 monitors. Field studies were conducted on a large coal storage pile at Madison, Indiana, to check the radiation detector moisture probe calibration curve. Density versus depth plots of the resulting data are included. Developmental work on density probes is also reported. It appears that a suitable probe may be constructed by selecting a gamma source of appropriate energy and strength, by surrounding a GM tube or a scintillator crystal with a filter to absorb all low energy scattered gammas, by using pulse height selection with the scintillator and discriminating low energy gammas, or by arranging suitable collimators around the source and detector. Continued study of the gamma spectrum presented to the GM tubes in commercial probes which are on hand is also reported. (For preceding period see TID-5905.) (J.R.D.)

**16927**

NEW ASPECTS IN THE TESTING OF WELDS WITH RADIOISOTOPES. Jenő Semadam (Power Plant Repair and Maintenance Enterprise, Hungary). Energia es Atomtech. 13, 75-8(1960) Jan.-Feb. (In Hungarian)

A break-proof method for mounting the capsules of isotope applicators is described. To simplify the computation of exposure time in radiography, the formula  $t = Rr^2 2^{x/f}/I d$  is written as  $t = (Rr^2/I) \cdot (2^{x/f}/d)$ , and a separate table is given for each of the two factors, (where  $t$  is exposure time in h;  $R$  is dose rate, in roentgens;  $r$  is source-to-film distance in cm;  $2^{x/f}$  is a simplified absorption coefficient, in which  $x$  is the thickness of the radiographed material and  $f$  is the half-value layer, both in cm;  $I$  is total source activity in mc; and  $d$  is the equivalent dose of the source). In testing the circumferential joint welds of steel pipes (720 mm in diameter and 9 mm thick) it is recommended that two instead of the usual three radiographs per weld be used. An experiment is described in which a G-M counter and a millenary scaler are set up 10 m from a 2.5-c  $\text{Cs}^{137}$  source, and two 4.5-mm steel plates are interposed at various distances from the source and from each other. The results clearly indicate the need of careful studies whenever a radiograph is to be made of a wall that is accessible only through an interposed layer. (JPRS)

**16928**

THE RANGE OF APPLICATION OF RADIOISOTOPES FOR INDUSTRIAL THICKNESS MEASUREMENTS. H. West-

meyer (Forschungsinstitut Manfred von Ardenne, Dresden). *Kernenergie* 1, 93-4(1958) Feb. (In German)

A short review is given of the accuracy attainable in radioisotope thickness measurements. (T.R.H.)

16929

THE USE OF A STRONG RADIATION SOURCE FOR DISINFECTION OF CEREAL GRAINS. A. V. Bibergal', U. Ya. (J.) Margulis, and E. S. Pertsovskii (Percovskij). *Kernenergie* 1, 133-9(1958) Feb. (In German)

A description is given of a project for a semi-industrial research installation for disinfection of cereal grains using  $\gamma$  rays from a  $\text{Co}^{60}$  source. The source is in the form of a hollow cylinder which is made up of 20 active rods with a total activity of 100,000 gram-equiv. of Ra. The installation has a water shield. The grain is automatically brought near the irradiator. The capacity of the installation is 1.85 tons/hr. For industrial grain-disinfection plants, the use of  $\text{Co}^{60}$  for irradiation is not practical because of the high cost. It is much more economical to use U fission products produced by the atomic power industry. Because of the low specific activity of fission products, the question of the most practical arrangement of the irradiators is of importance. Calculations show that irradiation cells are the most convenient. After a study of 3 types of irradiators (cylindrical, rod, and split) it was concluded that the split irradiator worked the most practically and had the greatest capacity per unit volume. The capacity of such a unit is 31 tons/hr with a total activity of  $3.72 \pm 10^8$  c. Because of its lower weight (including safety devices) it can be moved from one grain elevator to another. (tr-auth)

16930

ARGON-41 MEASURES NATURAL-GAS FLOW. Duane V. Kniebes, Philip V. Burkett, and William R. Staats (Inst. of Gas Tech., Chicago). *Nucleonics* 18, No. 6, 142-4; 146-7 (1960) June.

A method for measuring natural gas flow in pipes with  $\text{Ar}^{41}$  was developed to replace the ammonia method. It involves the injection of  $\text{Ar}^{41}$  into the pipeline at one point and detecting its 1.37-Mev gamma ray with a scintillation detector at a second point downstream, the elapsed time giving the flow rate. Several experiments were done with 400-mc  $\text{Ar}^{41}$  charges; detection was carried out at 8 and 17 miles downstream. It is concluded that under typical operating conditions 2 mc of  $\text{Ar}^{41}$  will give an accurate measurement 10 miles downstream. The design of the injector is given. (D.L.C.)

## ISOTOPE SEPARATION

16931 NYO-2347

Massachusetts Inst. of Tech., Cambridge.

AMMONIA DISTILLATION FOR DEUTERIUM SEPARATION. Gerald Thornton Petersen and Manson Benedict. May 16, 1960. 212p. Contract AT(30-1)-2249. OTS.

Thesis submitted by Gerald Thornton Petersen.

The relative volatility or separation factor for deuterium enrichment in ammonia distillation was measured at several pressures and deuterium concentrations. The knowledge of this information is very helpful in predicting costs of heavy water production by the ammonia distillation process. It has been stated by others, that the ammonia distillation process of heavy water production would be competitive with other developed methods only if the actual separation factor was at least 1.062 at low deuterium concentration. Unfortunately, the measurements do not indicate that the separation factor at low deuterium composition differs greatly from the vapor pressure pre-

diction ( $\alpha = 1.042$ ). Deutero-ammonia was synthesized by isotopic exchange between natural ammonia and heavy water. Equilibrium determinations were made using an Othmer still, modified for low temperature operation, and a concentric tube fractionating column. The ammonia samples were analyzed for deuterium content by converting them to water by flow through hot copper oxide, followed by a differential density determination using the falling drop method. (auth)

16932

SZILLARD-CHALMERS REACTION IN  $\text{HoO}$ . M. Vobecký (Czechoslovak Academy of Sciences, Prague). *Collection Czechoslov. Chem. Commun.* 25, 1506(1960) May. (In German)

Isotopic enrichment based on nuclear reflection in the reaction  $(n, \gamma)$  is shown to be taking place in holmium oxides. Conditions inducing such enrichment and the chemical nature of enriched fractions were studied. (tr-auth)

16933

ISOTOPE SEPARATION BY LIQUID-PHASE THERMODYFUSION. Karl F. Alexander (Zentralinstitut für Kernphysik, Rossendorf; Ger.). *Fortschr. Physik* 8, 1-41(1960). (In German)

The use of gas-phase thermodiffusion for isotope separation in preference to liquid-phase is based on groundless prejudice. Experimental data are given to support this viewpoint, with particular attention being given to thermodynamic effects and optimal dimensions in liquid-separation tubes. The thermodiffusion principle and theory are treated first, followed by consideration of the separation tube with constant cross section. A transport equation is set up and solved for this case, and factors and coefficients are determined. The ideal separation apparatus is then studied, the separation tube with variable cross section. The application of the principle in separation of U isotopes in liquid  $\text{UF}_6$  is discussed, and numerical examples given to compare with the gaseous diffusion process. (T.R.H.)

16934

ISOTOPIC ENRICHMENT IN BROMINE BY ELECTROLYTIC TRANSPORT IN MOLTEN ZINC BROMIDE. A. Lundén and A. Lodding (Chalmers Tekniska Högskola, Göteborg). *Z. Naturforsch.* 15a, 320-2(1960) Apr. (In German)

From a solution anode of zinc,  $\text{Br}^{79}$  was enriched by electrolytic transport in molten zinc bromide. The mass effect (relative difference of the migration velocities/relative difference of the masses) is given at  $\mu = -0.035 \pm 0.002$ . In the four halogenides of bivalent metals previously investigated, the mass effect of the anions satisfy the equation  $\mu = -0.054(1 \pm m^-/2.2 m^+)^{-1}$ . This equation was compared with the equation found earlier for the mass effect of the cations. (tr-auth)

16935

THE SEPARATION NOZZLE METHOD. III. SEPARATION OF URANIUM ISOTOPES. E. W. Becker and R. Schütte (Kernforschungszentrum, Karlsruhe, Ger.). *Z. Naturforsch.* 15a, 336-47(1960) Apr. (In German)

With a single-stage separating nozzle apparatus, the separation of the uranium isotopes in  $\text{UF}_6$  was determined in dependence on the intake pressure, the front and rear back pressures, the intake temperature, and the geometry of the separating system. With the experimental results the optimum operating conditions and the specific input magnitudes of the separating nozzle method were determined for the case of uranium isotopes. It is shown that the specific ideal isothermal compression work in the separating nozzle method is in the same order of magni-

tude as in the diffusion method. The weakest point of the separating nozzle method is shown to be the large specific intake volume which means relatively high investments for the compressors and tube power. (tr-auth)

16936

ISOTOPIC CONTAMINATION IN ELECTROMAGNETIC SEPARATION OF ISOTOPES. Charles Cassignol (Centre d'Etudes Nucleaires, Saclay, France). p.507-10 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In French)

The mechanisms producing isotopic contamination in the electromagnetic separation of isotopes are studied with the aid of the Separator of Saclay and an electrostatic analyzer in cascade. After a separate investigation the result that no contamination comes from the spreading of initial energies of ions, two principal mechanisms are emphasized: scattering and instability of the regime of the sources. The characters of each type of contamination arising from both mechanisms are described in some detail. A unique scheme of isotopic contamination is then derived from the partial ones. This scheme is successfully verified in several experimental separations. The applications concern principally the performances of magnetic cascades and more complex apparatus. It is found that the isotopic purities that such machines can deliver are extremely high. (auth)

## MATHEMATICS AND COMPUTERS

16937 NYO-2884

New York Univ., New York. Atomic Energy Commission Computing and Applied Mathematics Center.

FINITE AUTOMATA, PATTERN RECOGNITION AND PERCEPTRONS. Herbert Keller. Mar. 1, 1960. 50p. Contract AT(30-1)-1480. OTS.

A finite automaton is abstractly represented as a set function from one finite set into another. Many of the problems posed for finite automata are then simply described in terms of set functions with special properties. Some elementary results on the existence and uniqueness of such "discrimination functions" are presented. As a related example a finite automaton is described which can recognize a large variety of geometric patterns (or characters) when displayed in a rather general way. A finite automaton which is essentially a "perceptron" is described. In order that such a device represent a discrimination function it is shown that a specific product of two set functions must also represent a discrimination function. Some rather severe necessary conditions for solving the basic discrimination problem are then derived. Some final comments on approximate discrimination and generalizations of the basic formulation are given. (auth)

16938 TID-5972

Illinois. Univ., Urbana. Digital Computer Lab.

TECHNICAL PROGRESS REPORT. PART I. HIGH-SPEED COMPUTER PROGRAM. PART II. CIRCUIT RESEARCH PROGRAM. PART III. MATHEMATICAL METHODS. PART IV. SWITCHING CIRCUIT THEORY. PART V. ILLIAC USE AND OPERATION. PART VI. IBM 650 USE AND OPERATION. PART VII. GENERAL LABORATORY INFORMATION. Nov. 1959. 40p. Contract AT(11-1)-415. OTS.

In continuing work on high speed computers, drawings of all special connections in the  $A_{40}(S_{40})$  to  $Q_4(R_4)$  area were

completed in detail, together with a block diagram of data flow. The basic design of the assimilator, comparators, and decode logic was completed. In the circuit research program, the flow-gating system was redesigned, the transient behavior of transistors was investigated, and high-powered drivers for  $\pm 1$  v swings with 20  $\mu$ s rise-times were designed. A method for evaluation of integrals by the reduction of roundoff error in floating point quadrature is described. In switching circuit theory, codes for correcting errors in adjacent bits of a message were derived. The addition of a mixed number input routine and monthly uses of the Illiac are reported. Circuitry was installed in Illiac which enables the programmer to use the 8 v N (input) orders as shift orders, enabling unbiased multiplication by 2, 4, or 8 via shifting. The addition of two routines, a two-digit frequency count and a comparison post mortem routine, to the IBM 650 library is reported. (For preceding period see AECU-4660.) (C.J.G.)

16939 TID-5973

Illinois. Univ., Urbana. Digital Computer Lab.

TECHNICAL PROGRESS REPORT. PART I. HIGH-SPEED COMPUTER PROGRAM. PART II. CIRCUIT RESEARCH PROGRAM. PART III. MATHEMATICAL METHODS. PART IV. ILLIAC USE AND OPERATION. PART V. IBM 650 USE AND OPERATION. PART VI. GENERAL LABORATORY INFORMATION. Dec. 1959. 39p. Contract AT(11-1)-415. OTS.

Two designs for the logic of a speed-independent adder were completed for high-speed computers. One logic utilizes diode matrix logic, the other one uses AND-OR complexes. A workable design of a subcontrol system for a high-speed computer was achieved. Modifications to the core storage unit and a driver circuit are reported. The theoretical background of flow-gating action and transistor transients was re-examined. A 250-base driver was designed and tested. The six new routines added to the Illiac library are described and the monthly uses of Illiac discussed. The addition and revision of two routines to the IBM 650 library are discussed. (C.J.G.)

16940 TID-5974

Illinois. Univ., Urbana. Digital Computer Lab.

TECHNICAL PROGRESS REPORT. PART I. HIGH-SPEED COMPUTER PROGRAM. PART II. CIRCUIT RESEARCH PROGRAM. PART III. MATHEMATICAL METHODS. PART IV. ILLIAC USE AND OPERATION. PART V. IBM 650 USE AND OPERATION. PART VI. GENERAL LABORATORY INFORMATION. Jan. 1960. 43p. Contract AT(11-1)-415. OTS.

Selector connections for  $A_{hi}$  were simplified and the subtractor to be used during divide and floating point add, at the low ends of R and Q, was designed. The problem of decoding the range of "d" for the selection of a floating point addition sequence was investigated. The design of a memory element, the Reply Back Eccles-Jordan was completed. The circuits which drive large numbers of parallel diode-logic circuits were redesigned to reduce the number of driver types from 3 to 2. The second chassis of dropout detection equipment was constructed. Some results of a formulation of the emitter-follower oscillation theory and a study of the transient behavior of chains of transistor circuits are presented. Two IBM 650 sorting schemes using three magnetic tapes are described. An approximation to the exponential function was obtained. Various schemes for unnormalized floating point arithmetic were proposed. A description of eight new routines, added to the Illiac library, is given. Descriptions of one revised and four new routines which were added to the IBM 650 library are contained. (C.J.G.)

16941 TID-5978

Illinois. Univ., Urbana. Digital Computer Lab.  
TECHNICAL PROGRESS REPORT. PART I. HIGH-SPEED COMPUTER PROGRAM. PART II. CIRCUIT RESEARCH PROGRAM. PART III. MATHEMATICAL METHODS. PART IV. ILLIAC USE AND OPERATION. PART V. IBM 650 USE AND OPERATION. PART VI. GENERAL LABORATORY INFORMATION. Feb. 1960. 36p. Contract AT(11-1)-415. OTS.

Requirements for the operation of the Exponent Arithmetic Unit during multiplication, integer multiplication, and division were established. The core storage memory organization was completed. Tests run on both controls for the test unit revealed the necessity of modifying the speed independent control design to provide mutually exclusive UP and DOWN gates and to incorporate the new driver system. A flow gating read-in driver with a minimum input signal requirement of  $\pm 1.5$  v and an upper bound of  $\pm 3.5$  v was designed. The application of the Illiac program, SIR KITTSOLVER, to a wide variety of circuits is discussed. Descriptions of four new routines which were added to the Illiac library are given. (C.J.G.)

16942 NP-tr-450

THEORY OF RANDOM FUNCTIONS AND ITS APPLICATION TO PROBLEMS OF AUTOMATIC CONTROL.

(Teoriya Sluchaynykh Funktsii i ee Primenenie k Zadacham Avtomaticheskogo Upravleniya). V. S. Pugachev. Translated from a publication of the State Publishing House of Technical-Theoretical Literature, Moscow, 1957. 806p. OTS.

This paper was previously abstracted from the original language and appears in NSA, Vol. 12, as abstract No. 10799.

## METALS, CERAMICS, AND OTHER MATERIALS

### General and Miscellaneous

16943 AD-228433

Battelle Memorial Inst., Columbus, Ohio.

METALLURGICAL RESEARCH AND DEVELOPMENT IN ELECTRON DEVICES. Quarterly Progress Report No. 3 [for] June 15, 1959 through September 14, 1959. D. J. Maykuth, G. S. Root, R. I. Jaffee, J. B. Baker, G. B. Gaines, J. J. Vagi, and P. J. Rieppel. 31p. Contract DA-36-039 SC-78253.

Wires made of niobium and niobium alloys containing 0.65 zirconium or 40% tantalum show moderate room-temperature strengths and good ductility. Resistivity versus temperature curves for each of these materials were determined at 800 to 1700°C. Establishment of procedures for fabrication of unalloyed hafnium wires is reported. Joint strength of resistance-welded molybdenum-molybdenum cross-wire welds were shown to be a function of the mechanical properties of the recrystallized molybdenum metal in the weld areas. Other variables studied included the use of argon shielding gas, alternating current, and nickel foil sandwiches between the molybdenum wires. (J.R.D.)

16944 BMI-1440

Battelle Memorial Inst., Columbus, Ohio.

FLUIDIZED-BED COATING OF  $UO_2$  POWDER WITH NIOBIUM AND OTHER ELEMENTS. John M. Blocher, Jr., Neil D. Veigel, Joseph H. Oxley, Virginia M. Secret, and

Erlan E. Rose. May 25, 1960. 56p. Contract W-7405-Eng-92. OTS.

The chemical vapor deposition of niobium, molybdenum, tungsten, chromium, carbon, and niobium-vanadium alloys in a fluidized bed of  $UO_2$  powder particles was used to provide uniform, dense, nonporous coatings on the individual particles. In the case of niobium, which received major attention, hydrogen reduction of niobium pentachloride vapor was used as the vapor-deposition reaction. The most serious problem was that of maintaining bed fluidity and avoiding agglomeration. This problem was overcome to permit routine operation of the coating equipment. In the entire program of 68 experimental runs, only 1.1 per cent of the product was lost by agglomeration. In routine operation, this loss should be even lower. (auth)

16945 HW-48052

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

RECORDING SURFACE CONDITION BY REPLICATION.

J. R. Morgan. Jan. 29, 1957. Decl. Mar. 28, 1960. 21p. Contract W-31-109-Eng-52. OTS.

Replicas may be made of machined or etched surfaces of either normal or radioactive materials and preserved for study or reference after the part has been placed in service. Various replication techniques appear to be applicable. A Faxfilm technique was best suited for use on plutonium or other radioactive surfaces where remote handling was necessary. Photographs showing this technique are included. (auth)

16946 ISC-288(Suppl.II)

Ames Lab., Ames Iowa.

SINTERING MECHANISM AS APPLIED TO REFRactory OXIDES. A BIBLIOGRAPHY, 1955-1959. D. R. Wilder. Jan. 1960. 51p. OTS.

The second supplement to an original bibliography is presented. Included are citations and abstracts for much of the literature published between 1955 and 1959 pertaining to sintering mechanisms of refractory oxides. (J.R.D.)

16947 KAPL-M-MAG-2

Knolls Atomic Power Lab., Schenectady, N. Y.

ALPHA COUNTING RESULTS FOR REACTOR GRADE PURE ZIRCONIUM AND DILUTE ZIRCONIUM-URANIUM ALLOYS. M. A. Gerardi. Mar. 1, 1960. 20p. OTS.

Reactor-grade pure Zr and U-Zr alloy were alpha counted to determine if an unidentified alpha-emitting material was present. The results indicate that there is no significant concentration of alpha-emitting material other than natural U in the ingot of reactor-grade pure Zr that was checked. Unexpected high count rates for low U alloys might be attributed to the use of contaminated scrap and/or equipment in melting the strip fabrication. (W.L.H.)

16948 NAA-SR-3278

Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.

RATE OF ALLOYING OF URANIUM ALLOYS WITH STAINLESS STEEL (PART I. 1800 TO 2300°F). R. S. Neymark. June 1, 1960. 31p. Contract AT-11-1-GEN-8. OTS.

The rate of alloying between Type 304 stainless steel and metal fuels was investigated at 1800 to 2300°F. The alloying times were determined by experimental couples in vacuum and by short fuel elements with a sodium or  $NaK$  bond between the fuel and the cladding. The fuels included unalloyed uranium, uranium-molybdenum alloys, and a Th-7.6 wt. % U alloy. Within the stated temperature range, unalloyed uranium alloys rapidly with the stainless steel, U-10 Mo somewhat slower, and Th-7.6 U the slowest of

the fuels tested. The presence of a thin oxide film on the surface of a U-10 Mo fuel wafer substantially lengthens the time required to form the low-melting iron-uranium eutectic, whereas this effect is minor with unalloyed uranium. (auth)

**16949** NMI-2074

Nuclear Metals, Inc., Concord, Mass.

FUNDAMENTAL AND APPLIED RESEARCH AND DEVELOPMENT IN METALLURGY. Progress Report for January 1959. Mar. 9, 1959. Decl. May 18, 1960. 30p. OTS.

Beryllium Metallurgy. A small test program is under way to determine some of the characteristics of coextruded Be-clad U-2 wt. % Zr fuel elements. In an effort to ascertain exactly what happens when extruded and cross-rolled material is rolled at reductions in area 60:1, a Be single crystal has been rolled at a 12% reduction in Area at 1000°C. Uranium Metallurgy. Experiments to determine the reproducibility of Growth Index (GI) determinations were conducted. To determine the texture of as-cast ingot U billet, three one-inch diameter transverse x-ray samples were excised from the whole cross section of the three-inch diameter billet. Extrusions of two alloys having the nominal composition of Zr-3Mo-22Al and Zr-5Mo-2Al were carried out. The arc melting and induction melting of cast Th 5 to 15 wt. %-U alloy slugs is reported. A study of the effect of an interdiffusion heat treatment, and of subsequent heat treatments, upon the corrosion behavior of Zircaloy-2 clad U 2 wt. %-Zr containing artificial defects is reported. Studies of methods of fabrication of U tube, wire, and sheet are presented. Bonding experiments were conducted on V, U, and Nb sandwiches with the result that a V, U bond was attained by heating for one hour at 800 or 858°C. Thorium Metallurgy. Thorium alloys are being tested in high temperature water for the purpose of determining the most corrosion resistant alloys. Zirconium Metallurgy. The twelve Zr base alloys which were arc melted were hot rolled in the beta region at 1650°F and are now being corrosion tested. Other Problems. Another experiment to study the effect of various factors on extrusion shift was studied. Three multi-temperature extrusions of UO<sub>2</sub> were accomplished. Three V alloy ingots (2.5Ti-1Si, 10Ti-1Ta, and 10Ti-1Nb), 2 inches in diameter with lengths up to 4 inches were fabricated into  $\frac{1}{4}$ -inch  $\times$  0.020-inch wall tubing. (For preceding period see NMI-2073). (W.L.H.)

**16950** NMI-9800

Nuclear Metals, Inc., Concord, Mass.

STUDY OF GASES IN METALS. A Literature Survey. J. P. Pemsler. Aug. 17, 1959. 51p. Contract AF33(616)-6627. OTS.

A literature survey on the thermodynamics of solution of oxygen, nitrogen, and hydrogen in niobium and tantalum was made. Phase diagram and thermodynamic data are contained. Data on the effect of dissolved gases on the physical properties of the metals are discussed. Gas removal by vacuum annealing is discussed. (C.J.G.)

**16951** ORO-275

Carborundum Co., Niagara Falls, N. Y.

SYNTHESIS AND FABRICATION OF REFRACRYO URA- NIUM COMPOUNDS. Monthly Progress Report No. 6 [for] January 1 through January 31, 1960. K. M. Taylor, C. A. Lenie, P. E. Doherty, L. N. Hailey, and T. J. Keaty. Feb. 8, 1960. 7p. Contract AT(40-1)-2558. OTS.

Preparation of about 1200 g of uranium nitride powder is reported. Experiments indicated that synthesis of mononitride by decomposition of higher nitrides required pro-

longed heating at high temperature. Chemical analysis of uranium nitride for nitrogen was found to be difficult. Data from analysis of these compounds are tabulated for comparison with calculated composition. Sintering studies of uranium mononitride continued during the report period. Work on uranium silicide formation from the elements without quenching was continued, and effects of crucible material on the synthesis of the material were investigated. (For preceding period see ORO-254.) (J.R.D.)

**16952** WCAP-1565

Westinghouse Electric Corp. Atomic Power Dept., Pittsburgh.

THERMOELECTRIC NUCLEAR FUEL ELEMENT PROGRESS REPORT NO. 22. Gerald R. Kilp, W. P. Blankenship, P. V. Mitchell, and S. W. Sandberg. May 10, 1960. 21p. Contract AT(30-3)-500. OTS.

Work was initiated on the preparation of uranium sulfides, selenides, and tellurides by melting techniques. Uranium-selenium compounds were partially reacted in a quartz tube and then induction melted in sealed molybdenum crucibles at 1650°C. X-ray diffraction analysis revealed that the melted samples were more homogeneous than the hot-pressed material. Design of a new high-temperature apparatus for the measurement of thermoelectric properties is completed and construction is well underway. Irradiation experiments are being prepared and insertion is planned for Experimental Testing Reactor (ETR). A pre-notched center rod type of multi-junction thermoelectric element was successfully fabricated. Other multi-junction elements consisted of prefabricated couple units assembled in case tubes for swaging. Attempts to swage preassembled wafers into electrically insulated outer and inner clads are continuing. Hardware was prepared for a number of bench tests and in-pile experiments. Work was started on the new Preliminary Reactor Arrangements task. Objectives were set up and calculations started. Five per cent overall core electrical efficiency appears feasible in an all-thermoelectric, low-pressure, light-water, 500 kw(e) d-c unit featuring natural-flow coolant (no primary coolant pumps). (auth)

**16953** AEC-tr-4097

METALLIC COMPOUNDS. I. I. Kornilov and B. K. Vul'f. Translated for Los Alamos Scientific Lab. from Uspekhi Khim. 28, 1086-1113(1959). 38p. JCL or LC.

A review is presented in which analyses of metallic compound properties are illustrated by use of typical examples of the large variety of these compounds found in alloys. Included is a classification of metallic compounds along with discussions of conditions for formation of these compounds and their solid solutions, general properties, and characteristics of the separate classes. (J.R.D.)

**16954**

COLUMBIUM ALLOYS TODAY. CONSIDERATIONS IN DESIGN AND FABRICATION OF STRUCTURES. L. P. Jahnke, R. G. Frank, and T. K. Redden. Metal Progr. 78, 76-80(1960) July.

A summary of the salient results of the last few years of research on the properties of niobium and its alloys is presented. Oxidation characteristics of niobium alloys compared with molybdenum at 2000°F are given graphically. The properties of the F-, FS-, and D-alloys are compared with unalloyed niobium. Alloying agents are principally molybdenum, titanium, tungsten, and zirconium. (B.O.G.)

**16955**

MICROSCOPIC STUDY OF THE COMPOUND Al<sub>4</sub>C<sub>3</sub> IN THE

STRUCTURE OF CAST SAMPLES OF 99.99 AND 99.5% Al. Margarete Schippers. Z. Metallk. 51, 256-8(1960) May. (In German)

The mode and the characteristics are reported for the compound  $Al_4C_3$  formed when pure or purest aluminum is cast under vacuum and at high temperatures in graphite crucibles. (auth)

16956

THE EFFECT OF TEMPERATURE CYCLES AND CORROSION BEHAVIOR ON THE RATE OF GRAIN BOUNDARY MIGRATION IN ALUMINUM BICRYSTALS. Frank Haessner and Wilhelm in der Schmitten (Universität, Göttingen). Z. Metallk. 51, 268-70(1960) May. (In German)

The speed with which a nucleus grows in a strained Al matrix decreases with the time and is lower with more roughly etched surfaces. Thermal cycling increases the reduction of the speed. The influence of the cycling is lower with purer metals. It is assumed that the cycling produces thermal stresses which cause changes in the distribution of the impurities resulting in an abnormal recovery of the stored deformation energy. (auth)

16957

STRUCTURE AND MAGNETIC PROPERTIES OF ALUMINUM-MANGANESE ALLOYS WITH MORE THAN 25 AT. % Mn. Werner Köster and Ernst Wachtel (Max-Planck-Institut für Metallforschung, Stuttgart). Z. Metallk. 51, 271-80(1960) May. (In German)

The system aluminum-manganese was investigated in the range 29.5 to 100 at.% Mn, and the existing phase diagram was corrected. Particularly, the magnetic properties of the alloys were investigated and interpreted. (auth)

16958

DAMPING AND SHEAR MODULUS OF ZIRCONIUM AND ZIRCONIUM-HYDROGEN ALLOYS. Karl Bungardt and Hans Preisendanz (Forschungsinstitut der Deutschen Edelstahlwerke AG, Krefeld, Ger.). Z. Metallk. 51, 280-9 (1960) May. (In German)

The influence of the temperature and of different heat treatments on the damping capacity and the modulus of rigidity of zirconium and of zirconium with hydrogen in solution was determined. The hydrogen has different effects which are discussed in detail. (auth)

16959

HAFNIUM AS ALLOYING ELEMENT IN COPPER, IRON, AND NICKEL. Rudolf Reinbach (Laboratorium der Vacuumschmelze AG, Hanau, Ger.). Z. Metallk. 51, 292-4(1960) May. (In German)

The electrical resistance, the thermal EMF, the coefficient of thermal expansion, and the hardness of copper, iron, and nickel with different additions of hafnium were measured and the solubility of hafnium in copper, iron and nickel was determined. The influence of the addition of hafnium on the recrystallization of copper, iron and nickel was investigated, too. (auth)

## Corrosion

16960 BMI-1437

Battelle Memorial Inst., Columbus, Ohio.

DEVELOPMENT OF CORROSION-RESISTANT NIOBIUM-BASE ALLOYS. Daniel J. Maykuth, William D. Klopp, Robert I. Jaffee, Warren E. Berry, and Frederick W. Fink. May 12, 1960. 91p. Contract W-7405-eng-92. OTS.

The hot-water corrosion resistance and mechanical properties of niobium and a number of its alloys were

evaluated relative to their usefulness in pressurized-water thermal reactors. Unalloyed niobium was found to be rapidly attacked by 600 and 680°F water and 750°F steam. A number of alloying additions were found which markedly improve the corrosion resistance of niobium. Of these, binary and ternary combinations of chromium, molybdenum, titanium, vanadium, and zirconium were among the most effective. Many of these alloys exhibited as low or lower weight gains than those obtained for Zircaloy-2 under similar test conditions. Most of the niobium-base alloys tested for strength exhibited excellent resistance to creep at temperatures up to 1200°F under stresses through 20,000 psi. (auth)

16961 HW-62690

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

ADDITIONAL TESTS ON THE CORROSION OF CARBON STEEL FOLLOWING THE TURCO-4512 DECONTAMINATION PROCESS. A. P. Lerrick. Nov. 25, 1959. 9p. Contract W-31-109-Eng-52. OTS.

Carbon steel, 304 stainless steel, and Zircaloy-2 coupons were treated in Turco-4512-2b inhibited phosphoric acid decontaminating solution and then charged in a pH 10, 290°C recirculating water loop. The decontaminating solution pretreatment did not affect the corrosion behavior of 304 s/s or Zircaloy-2 but did increase the carbon steel initial penetrations by a factor of 2 and the corrosion product film weights by a factor of 1.7 over those of the nontreated carbon steel coupons. The corrosion rate of the carbon steel coupons was not increased by the decontaminating solution pretreatment. (auth)

16962 HW-62820

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

CORROSION OF TYPE 202 STAINLESS STEEL IN HIGH TEMPERATURE WATER. A. P. Lerrick. Dec. 11, 1959. 8p. Contract AT(45-1)-1350. OTS.

Two heats of 202 stainless steel and one heat of 304 stainless steel were corrosion tested in a recirculating loop using pH 10 water at 290°C. Corrosion rates for both alloys were found to be 0.0044 mils/year. (J.R.D.)

16963 IS-115

Ames Lab., Ames, Iowa.

A STUDY OF THE HIGH-TEMPERATURE AIR OXIDATION OF YTTRIUM METAL. O. N. Carlson, F. A. Schmidt, and R. L. Wells. Mar. 1960. 32p. Contract W-7405-eng-82. OTS.

A survey was made of the high-temperature oxidation of yttrium metal and its effect on hardness. Corrosion of the metal was very slow at 450°C, but increased rapidly with temperature, becoming very severe at 925°C. Oxidation was found to increase the hardness of yttrium metal due to the diffusion of oxygen into the metal lattice. (auth)

16964 MND-E-2326

Martin Co. Nuclear Div., Baltimore.

ERDL-NPFO—CORROSION TESTING OF INCONEL AND CROLOY 16-1 HEAT EXCHANGERS. Mar. 1960. 128p. Contract DA-44-009-ENG-3581.

Two sets of model heat exchangers and five miniature heat exchangers were tested in dynamic and static pressurized water loops, respectively. The model heat exchangers were MOD SG-5 and MOD SH-5 with Croloy 16-1 tubes and MOD SG-6 and MOD SH-6 with Inconel tubes. The miniature heat exchangers MIN 4, MIN 5, and MIN 6 had Croloy 16-1 tubes; MIN 8 and MIN 9 had Inconel tubes. Miniature heat exchangers MIN 4, 5, and 6 were tested for 2578, 941, and 2767 hours, respectively. The testing of

MIN 4 and 5 was discontinued after leaks occurred in each; MIN 6 did not leak. Miniature heat exchangers MIN 8 and 9, both fabricated completely of Inconel, were service tested 5296 and 2631 hours, respectively. Model heat exchangers MOD SG-5 (steam generator) and SH-5 (superheater) with Croloy 16-1 tubes were service tested 4253 hours. Model heat exchangers MOD SG-6 and SH-6, a steam generator and superheater with Inconel tubes, were service tested 3819 hours. The performance of the Croloy 16-1 heat exchangers, although superior to other materials tested in the past, fell far short of the performance shown by the Inconel test vessels. The Croloy 16-1 tubes pitted in all of the vessels; pitting was particularly bad in the superheater. Measurements were made which gave some qualitative indication of the heat transfer characteristics of the model steam generators. It was found that these characteristics were different for the exchanger containing Inconel tubes (MOD SG-6) as compared to those of the unit containing Croloy 16-1 tubes (MOD SG-5). (auth)

**16965** NP-tr-445

THE ELECTROCHEMICAL AND CORROSION BEHAVIOUR OF STEEL AND NICKEL ELECTRODES IN SULPHURIC ACID SOLUTIONS SUBJECTED TO THE ACTION OF  $\gamma$  RAYS. N. Ya. Bune, Ya. M. Kolotyrkin, and G. S. Tyurikov. Translated by R. W. Hummel (U.K.A.E.A. Atomic Energy Research Establishment) from Zhur. Fiz. Khim. **32**, 2679-85 (1958). 11p. JCL or LC.

This paper was previously abstracted from the original language and appears in NSA, Vol. 13, as abstract No. 22107.

**16966**

HYDROGEN CORROSION IN ORGANIC REACTOR COOLANTS. PART 1. HYDRIDING OF ZIRCONIUM. V. H. Troutner (General Electric Co., Richland, Wash.). Corrosion **16**, 281t-3t (1960) June.

Zirconium and Zircaloy-2 were exposed to organic reactor coolants at temperatures up to 400°C under various conditions of constant hydrogen partial pressure and low water concentration. The hydriding of zirconium was found to be independent of the presence of the organic coolant and dependent on the temperature, hydrogen partial pressure, and the presence of an oxide film on the metal. (auth)

**16967**

HYDROGEN CORROSION IN ORGANIC REACTOR COOLANTS. PART 2. HYDROGEN CORROSION OF URANIUM. V. H. Troutner (General Electric Co., Richland, Wash.). Corrosion **16**, 283t-5t (1960) June.

Uranium was exposed to organic reactor coolants at temperatures up to 400°C under various conditions of constant hydrogen partial pressure and low water concentration. Uranium reacts with hydrogen to form uranium trihydride according to the rate law: rate =  $k(P - P_D)^{2.5}$ . The presence of the organic coolant reduces the rate to an eighth of the rate in dry hydrogen. At 375°C and above,  $UH_3$  reacts with the organic coolant to form UC and in a confined system this reaction can result in an autocatalytic destruction of uranium. (auth)

**16968**

THE LIQUID METAL CORROSION PROBLEMS. Alois Dvořák (Akimov State Univ., Prague). Jaderná energie **6**, 155-82 (1960). (In Czech.)

Recent research on the specific character of corrosion of construction materials by liquid metals as well as factors influencing the development of these corrosion processes are reported. The characteristic effects of corro-

sion by liquid metals, the principles of corrosion test methods, and the main methods of increasing the corrosion resistance of construction materials are given. (auth)

**16969**

INTERCRYSTALLINE CORROSION OF NICKEL-MOLYBDENUM AND NICKEL-MOLYBDENUM-CHROMIUM ALLOYS. Hubert Gräfen and Georg Böhm (Badische Anilin- & Soda-Fabrik AG, Ludwigshafen am Rhein, Ger.). Z. Metallk. **51**, 245-52 (1960) May. (In German)

In order to investigate intercrystalline corrosion of Ni-Mo and Ni-Mo-Cr alloys, a short-time test was developed and grain-boundary breakdown diagrams were represented for three alloys. The precipitations leading to corrosion-susceptibility were identified by x-ray-diffraction analysis and the mechanism of intergranular corrosion was explained. The cause of intercrystalline attack is obviously a local decrease of corrosion resistance by grain-boundary precipitation, which effects a reduction of Mo (Ni-Mo alloys) or Cr and Mo (Ni-Mo-Cr alloys) in the grain edges. (auth)

**16970**

ALLOYS OF GOLD WITH CHROMIUM, MOLYBDENUM, AND TUNGSTEN. Ernst Raub (Forschungsinstitut für Edelmetalle und Metallchemie, Gmünd, Ger.). Z. Metallk. **51**, 290-1 (1960) May. (In German)

The phase diagram gold-chromium was investigated. The alloys crystallize peritectically; the saturation concentration of the chromium mixed crystal depends strongly on the temperature. The phase diagram gold-molybdenum, already known, was confirmed. In the system gold-tungsten, there was no formation of an alloy up to temperatures close to the boiling temperature of gold. (auth)

## Fabrication

**16971** APAE-Memo-258

Alco Products, Inc., Schenectady, N. Y. SPECIFICATIONS AND FABRICATION PROCEDURES FOR SM-1A CORE II STATIONARY FUEL ELEMENTS. May 13, 1960. 91p. Contract AT(30-3)-326. OTS.

Stainless steel-base fuel components of thin plate-type construction and containing a dispersion of  $UO_2$  were successfully employed in powering the Army Package Power Reactor (SM-1). The component is designed for radioactive service in pressurized water and consists of eighteen composite fuel plates joined into an integral unit or assembly by brazing. Specifications are presented which cover loadings, materials, and processing. A list of applicable drawings and a process flow diagram are included. (auth)

**16972** APAE-Memo-259

Alco Products, Inc., Schenectady, N. Y. SPECIFICATIONS AND FABRICATION PROCEDURES FOR SM-1A CORE II NEUTRON ABSORBER SECTIONS. May 13, 1960. 56p. Contract AT(30-3)-326. OTS.

The composite plates of the absorber section consist of compacts of europium oxide-stainless steel clad with stainless steel by hot roll-bonding. Specifications are given to cover materials, dimensional and finish requirements, tests for qualification of absorber plate fabrication, the conformance of fabrication procedure, and the manufacturing procedures. Drawings are also included. (M.C.G.)

**16973** BMI-1195

Battelle Memorial Inst., Columbus, Ohio.

NEW BETA HEAT-TREATING SALT BATHS FOR REDUCING HYDROGEN PICKUP BY URANIUM RODS. Law-

rence L. Lortscher, Karl A. Sense, and Robert B. Filbert, Jr. June 18, 1957. Decl. Feb. 4, 1960. 28p. Contract W-7405-eng-92. OTS.

Hydrogen pickup by U was studied in different salt mixtures at 1350°F under dry and wet atmospheres. Of the salts investigated, 50 wt.% KCl-50 wt.% NaCl and 50 wt.% KCl-50 wt.% Na<sub>2</sub>CO<sub>3</sub> gave the best results for low H pickup, corrosion of U, and salt stability at 1350°F. These salt mixtures resulted in H pickup of less than 3 ppm under dry atmospheres and less than 5 ppm under wet atmospheres. By comparison, the two salt mixtures, 44 wt.% Li<sub>2</sub>CO<sub>3</sub>-56 wt.% K<sub>2</sub>CO<sub>3</sub> and 25 wt.% Li<sub>2</sub>CO<sub>3</sub>-75 wt.% K<sub>2</sub>CO<sub>3</sub>, resulted in H pickup greater than 5 ppm under dry atmospheres and as high as 13 ppm under wet atmospheres. Pilot-plant-scale studies showed that the average final H content of the U specimens treated in the 50 wt.% KCl-50 wt.% NaCl baths was 0.47 ppm. The corresponding average for the 50 wt.% KCl-50 wt.% Na<sub>2</sub>CO<sub>3</sub> baths was 0.77 ppm. Preliminary studies of corrosion of materials of construction in the pilot-plant-scale baths indicated that Type 330 stainless steel was more resistant to attack than mild steel and Types 304, 416, and 446 stainless steels. (auth)

**16974 HW-35511**

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

END SEALS FOR "CORED" SLUGS. E. A. Smith. Mar. 1, 1955. Decl. May 18, 1960. 10p. Contract W-31-109-Eng-52. OTS.

Four schemes were considered for installing closure plugs in cored slugs. One was developed to a workable state and partially evaluated using a flat, chambered U disc crimped into a counterbored recess at each end of the bare slug after pickling. This process provides a leak-free closure and offers economic benefits for production. (F.S.)

**16975 HW-64731**

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

ZIRCALOY PROCESS TUBE MONITORING. P. J. Pankaskie. Apr. 11, 1960. 8p. Contract AT(45-1)-1350. OTS.

The Zircaloy tube monitoring program was devised to supplement the physical and mechanical properties data on Zircaloy-2 in-reactor process tubes for continued assurance of integrity and operating safety. (W.L.H.)

**16976 HW-64796**

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

ULTRASONIC CLEANING OF FUEL ELEMENT COMPONENTS. C. A. Strand. Apr. 19, 1960. 5p. Contract AT(45-1)-1350. OTS.

Slight improvements in aluminum component cleaning and wetting were experienced when the Branson ultrasonic cleaning equipment was used in a modified cleaning tank to increase the energy transmitted to the alkaline cleaning solution. A slight improvement in component wetting was also noted when ultrasonic agitation was used in the deoxidizer tank. Large improvement in cleaning of new sleeves was observed. New sleeves subjected to a single ultrasonic cycle produced unusually clean fuel elements, without the common dull, dark effect. No sleeve smoking was observed on the ultrasonically cleaned sleeves. (M.C.G.)

**16977 NMI-1219**

Nuclear Metals, Inc., Concord, Mass.

BERYLLOM-CLAD URANIUM ELEMENTS, FABRICATION DEVELOPMENT BY MULTI-TEMPERATURE EXTRUSION, AND DIMENSIONAL STABILITY ON THERMAL CY-

CLING. J. Greenspan. Mar. 18, 1960. 41p. Contract AT(30-1)-1565. OTS.

Some development studies are described concerning the coextrusion of beryllium with either uranium or uranium having small alloy additions. Some test data on the general integrity of extruded rods are reported. (auth)

**16978 NMI-4375**

Nuclear Metals, Inc., Concord, Mass.

EVALUATION OF ZIRCALOY-CLAD U-2 w/o ZR ALLOY TUBE NO. 23. EXTRUSION NO. 18394. D. F. Kaufman and R. G. Jenkins. Feb. 19, 1959. 36p. Contract AT(30-1)-1565, Sponsor Agreement No. S-31. OTS.

The evaluation data presented show that Tube No. 23 does not meet irradiation specifications because of a pit-type defect in the outer cladding. The tube otherwise meets irradiation specifications in all characteristics except maximum clad thickness in the taper regions (+0.9 mil OD, 1.2 mils ID out of specification which restricts taper clad thickness to 16 mils maximum), ultrasonic sensitivity threshold over rear taper (+0.1 out of specification which restricts the threshold of detection of non-bond to a maximum of 1.6), and final straightness (+1/16 inch out of specification which restricts maximum bow to 1/8 inch). Of all the above deviations from specification, only the large pit defect in the cladding is considered serious by du Pont and has resulted in a recommendation that the tube not be used for irradiation. The tube is otherwise considered representative of a lot of nine tubes, and has been cut up to provide specimen material for corrosion and other destructive tests. (auth)

**16979 ORO-273**

Clevite Corp. Mechanical Research Div., Cleveland. FUEL-BEARING FIBERGLAS IN ALUMINUM BASE FUEL ELEMENTS. Third Quarterly Report [for] November 1, 1959 to January 31, 1960. R. H. Baskey. Feb. 15, 1960. 20p. Project 50224G. Contract AT(40-1)-2557. OTS.

Fiberglas-reinforced aluminum core material was produced by press consolidation of aluminum-coated fiberglas. A hot pressing operation furnished materials with an average density of 98.5% of theoretical. Cold pressing followed by hot pressing produced materials with an average density of 99.1% of theoretical. Fabrication techniques for fiberglas-reinforced aluminum were developed with uranium-free glass to the point where crack free core material was produced, both clad and unclad. The material was picture framed, heated to 1000°F, and hot rolled with reductions of approximately 30% per pass. As-hot pressed compacts were produced with 60.8% by weight of aluminum and 39.2% by weight of fiberglas. Specimens of this material in which the fibers were oriented along the specimen axis exhibited a tensile strength of 25,250 psi at room temperature, and maintained a tensile strength of approximately 18,450 psi at 250 to 800°F. The tensile strength of the as-hot pressed material in a transverse direction to the oriented fibers was 16,700 psi at room temperature, decreasing rapidly to 4,500 psi at 600°F. (For preceding period see ORO-224.) (J.R.D.)

**16980 ORO-277**

Clevite Corp. Mechanical Research Div., Cleveland. FUEL BEARING FIBERGLAS IN ALUMINUM BASE FUEL ELEMENTS. Monthly Progress Letter No. 11 for April 1, 1960 to April 30, 1960. R. H. Baskey. May 10, 1960. 3p. Contract AT(40-1)-2557. OTS.

Fabrication techniques designed to eliminate the ripple effect produced in clad plates containing uranium-bearing

fiberglas-core sections were investigated. The variables contributing to the rippled appearance are: edges of the pressed compacts, temperature of open and clad rolling, and reduction ratio. The reduction in area of clad tensile specimens taken transverse to the rolling direction varied from 36 to 55% from room temperature to 1000°F. (See also ORO-247). (C.J.G.)

**16981** TID-5985

Sylvania-Corning Nuclear Corp., Bayside, N. Y.  
INFORMAL LETTER PROGRESS REPORT, APRIL 1960.  
12p. OTS.

The preparation of stoichiometric  $UO_2$  samples doped with various concentrations of  $BaO$  and  $ZrO_2$  was continued. Measurements were made to determine if the presence of  $Y_2O_3$  produced a significant change in the thermal conductivity of  $UO_2$ . In contrast to previous experiments, a decrease rather than increase in thermal conductivity was found. The receipt of a Gaertner Interferometer initiated activity on thermal expansion measurements. Samples of three different  $UO_2$  powder mixtures were vibration packed in the sonic frequency range and five others were packed at higher ultrasonic frequencies. Four samples, including two hot isostatically pressed, were autoclave tested at 750°F and 1,500 psi for 36 hours. The design of irradiation samples is being reviewed from the standpoint of internal pressure. Studies of Thermenal (iron-aluminum alloy) and niobium cladding of  $UO_2$  are being made. (M.C.G.)

**16982** WADD-TR-60-52

Linde Co., Newark, N. J.

RESEARCH INVESTIGATION TO DETERMINE THE OPTIMUM CONDITIONS FOR GROWING SINGLE CRYSTALS OF SELECTED BORIDES, SILICIDES AND CARBIDES. [Period] covered: March 1959 to February 1960. A. D. Kiffer. Mar. 14, 1960. 30p. Project title: CERAMIC AND CERMET MATERIALS. Task title: CERAMIC AND CERMET MATERIALS DEVELOPMENT. Contract AF33(616)-6326. OTS.

Methods of producing selected crystals in the refractory hard metals class for mechanical and other property determinations were studied. A Verneuil-type process using an arc heat source and argon shield gas was employed. Single crystal boules of titanium diboride and tungsten disilicide,  $\frac{1}{4}$ -inch diameter and up to  $4\frac{1}{2}$ -inches long, were made, however, most of them cracked upon cooling. The largest single crystal pieces recovered were  $\frac{1}{4}$ -inch diameter and over  $\frac{1}{2}$ -inch long. Dimolybdenum carbide boules had large sections of a "single crystal"  $Mo_2C$  matrix containing about 10% by volume of another phase distributed uniformly through it. No  $Mo_2C$  single crystal pieces free from this phase were made. In very limited work with ditungsten pentaboride only polycrystalline boules were produced. A major problem was encountered in getting powders suitable for Verneuil-type crystal growth. Best results were obtained from compounds prepared by fusing commercially available pure elements and crushing the lumps into a suitable particle size fraction. Process improvements and purer powders are required to produce better quality  $TiB_2$  and  $WSi_2$  crystals. More experimental information is required on the molybdenum-carbon and the tungsten-boron systems. (auth)

**16983** WAPD-TM-172

Westinghouse Electric Corp., Bettis Plant, Pittsburgh.  
FURNACE BRAZING OF ZIRCALOY. E. R. Slaughter.  
Jan. 1959. Decl. Mar. 30, 1960. 24p. Contract AT-11-1-GEN-14. OTS.

The furnace brazing of Zircaloy or Zircaloy-clad nuclear reactor components was investigated. The strength

and corrosion resistance of brazements were determined and techniques were developed for replacing the brazing alloy to prevent contamination and to maintain dimensional stability during brazing. Brazements of high strength and adequate dimensional accuracy were produced, but the brazing cycles impaired the corrosion resistance of Zircaloy in high-temperature steam and water. (auth)

**16984** Y-1293

Union Carbide Nuclear Co. Y-12 Plant, Oak Ridge, Tenn.  
EFFECT OF ANNEALING TIME AND WORKING ON INDICATED THICKNESS OF URANIUM. Robert B. Burditt.  
Dec. 31, 1959. 13p. Contract W-7405-eng-26. OTS.

An investigation was made into the effect of the length of time for which warm-rolled uranium sheet was salt annealed on the indicated sheet thickness obtained ultrasonically. Tests were also made to determine the effect of various per cent cold reductions on the apparent ultrasonic thickness. Test results and an analysis of their possible significance are included. (auth)

**16985** NP-tr-436

France. Commissariat à l'Énergie Atomique. Centre d'Etudes Nucléaires, Saclay.  
ELECTROLYTIC DEPOSITION OF NICKEL ON URANIUM. G. Baudin, G. Chauvin, H. Coriou, and J. Hure. Translated by S. Asher (U.K.A.E.A. Atomic Energy Research Establishment) from Report CEA-815. Nov. 1959. 12p. JCL or LC.

A method of nickel electrodeposition on uranium in an aqueous bath containing nickel sulfate and ammonium chloride is described. Other electrolytic media such as watts baths and fused salts were also experimentally examined. Included are discussions of surface treatment, testing for oxide films on the uranium surface, and parameters of optimum coating thickness. (J.R.D.)

**16986**

ELECTRODES FOR WELDING TYPE 347 STAINLESS. Thomas J. Moore (Arcos Corp., Philadelphia). Metal Progr. 78, 93-100; 162; 164; 166(1960) July.

The results of testing have confirmed the idea that cracking of weld metal in stainless steel is clearly an inverse function of ferrite content. For niobium-containing alloys the ferrite transforms to brittle sigma during exposure to elevated temperatures. Stress rupture data indicate that the electrode compositions H, C, and A appear suitable to join Type 347 stainless, since they are stronger than the base metal. Compositions 16-8-2, H, and C possess superior tensile ductility to the partially ferrite Type 347 weld metal (Composition A) in the 1500 to 2000°F range. Corrosion tests show that the Nb-bearing welds possess acceptably low corrosion rates in the as-welded and annealed conditions. The probable field of application for each electrode composition is outlined. (B.O.G.)

**16987**

AUTOMATIC TUBE WELDING INCREASES RELIABILITY, LOWERS REJECT RATE. L. H. Hawthorne (Revere Copper and Brass, Inc., Rome, N. Y.). Metal Progr. 78, 131-2(1960) July.

An automatic welding gun is described which employs a gas-shielded tungsten-arc process implemented in such a manner that the human element in the operation is not a factor in welding quality. This process was developed to obtain tube-to-tube sheet joints of high integrity and consistency, which are necessary for higher efficiencies in the field of atomic power. Of the 15,000 welds in the condensers of the N. S. Savannah, 69 welds were found to be defective, which represents a reject rate of 0.46%. The

speed with which welding is accomplished is such that welding usually can be done with the tube sheet in the vertical position. (B.O.G.)

16988

NEUTRON-ABSORBING BRICKS MADE FROM  $\text{CaB}_6$ . J. W. Butler (U. S. Naval Research Lab., Washington, D. C.). *Nuclear Instr. & Methods* 7, 201-3 (1960) May. (In English)

A technique is described for making relatively inexpensive neutron-absorbing bricks from commercially available  $\text{CaB}_6$  powder. The bricks are  $2 \times 3 \times 5$  in., and are strong enough to withstand normal handling. They last indefinitely; the ones described are now 7 years old, used and stored under normal room temperatures and humidities. The procedure is to make a thick, dry mud with the powder and water, followed by compression in a mold at pressures of about 1 ton/in.<sup>2</sup> or more. The bricks are then baked for 2 hours or longer at a temperature of about 750°C. (auth)

16989

AMMONIUM BIFLUORIDE—A SUPERIOR ETCHANT FOR ZIRCALOY. Robert B. Flanders, R. A. Breed, and B. Wessling (M & C Nuclear, Inc., Attleboro, Mass.). *Nucleonics* 18, No. 6, 126-7 (1960) June.

Ammonium bifluoride ( $\text{NH}_4\text{F} \cdot \text{HF}$ ) is suggested as a substitute for HF as an etchant for Zircaloy components.  $\text{NH}_4\text{F} \cdot \text{HF}$  baths are comparable to HF baths in cost and can be made up by inexperienced men. Tests show  $\text{NH}_4\text{F} \cdot \text{HF}$  to be as good as HF as far as post-etching oxidation is concerned, and superior in etching rates and imparting mirror finishes to Zircaloy samples after being laden with dissolved Zircaloy. (D.L.C.)

## Properties and Structure

16990 60-GL-20

General Electric Co. General Engineering Lab., Schenectady, N. Y.

INVESTIGATION OF THE SLIDING BEHAVIOR OF A NUMBER OF ALLOYS UNDER DRY AND WATER LUBRICATED CONDITIONS. R. E. Lee, Jr. Jan. 22, 1960. 25p. OTS.

An investigation was made to determine the sliding characteristics of a number of alloys under consideration for use as components in a pressurized reactor. The materials were studied under dry sliding (74°F), and water lubricated conditions (200°F). The wear and surface damage of Inconel sliding against itself was considerably more severe than the austenitic AISI 304 stainless steel in combination with itself. Replacing one of the Inconel-Inconel sliding members with Zircaloy 2, significantly reduced the wear and surface damage. The application of protective coatings resulted in considerable improvement over that of the conventional (uncoated) material combinations. The coatings that proved effective in reducing the wear and surface damage of Inconel were: Stellite 6 (overlay), Colmonoy 6 (overlay), and Hard chromium plate. (auth)

16991 AECU-4728

Syracuse Univ., N. Y. Metallurgical Research Labs. LOW CYCLE FATIGUE OF PRESSURE VESSEL MATERIALS. Interim Technical Report No. 5. George Sachs, W. W. Gerberich, and V. Weiss. Jan. 1960. 47p. Contract AT(30-1)-2141. (MET575-601IT5). OTS.

Low-cycle strain-controlled fatigue tests in tension-compression and in bending were conducted on two pressure vessel materials (A-302 steel and 5454-0 aluminum) and one additional aluminum alloy (2024-T4). It was found

that for tension compression cycling the experimental data are well approximated by the equation  $N = [(\epsilon_F - \epsilon_0)/\epsilon_{TR}]^2$ . In bend cycling the same general trend was observed, however, the average slope of the  $\log \epsilon$  vs.  $\log N$  curves was less than that for tension-compression cycling. The effects of mean strain or prestrain, of biaxiality, and of test temperature were studied. The effects of prestrain or mean strain (cold working) and of biaxiality diminished rapidly and became insignificant beyond 10,000 cycles. The effects due to differences in the ductility of different materials and to different test temperature were retained up to approximately 100,000 cycles. (auth)

16992 APEX-420

Illinois Inst. of Tech., Chicago. Armour Research Foundation

PHASE DIAGRAM STUDIES. Progress Report No. 2 [for] April 1-June 30, 1958. R. F. Domagala. July 2, 1958. Decl. June 11, 1959. 15p. For General Electric Co. Aircraft Nuclear Propulsion Dept. Contracts AF33(600)-38062 and AT(11-1)-171. OTS.

The alloys studied were: Y-Fe, Y-Ni, and Y-Cu. Based principally on the metallographic evaluation of as-cast samples and samples annealed at and quenched from 700 and 800°C, tentative phase diagrams were constructed. A cursory melting point study was completed for the Y-Cu alloy. (W.L.H.)

16993 BMI-1158

Battelle Memorial Inst., Columbus, Ohio.

CHARACTERIZATION OF INCLUSIONS IN DINGOT URANIUM. Donald M. Cheney and Ronald F. Dickerson. Jan. 11, 1957. Decl. Feb. 4, 1960. 22p. OTS.

The nonmetallic inclusions in both as-reduced and fabricated dingot U were studied for comparison with those in ingot U. Special attention was paid to the hydride for the purpose of determining the amount and distribution in the various types of U. The types and distribution of other inclusions were also studied. It was found that the dingot U was of a higher quality than ingot U and was comparable to as-reduced derby U on the basis of over-all inclusion count. The H content in dingot U, however, was found to be appreciably higher than in either ingot or derby U. (auth)

16994 HW-35544

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

BEND AND IMPACT TESTS ON POROUS ALUNDUM FILTER MATERIAL. C. L. Boyd. Mar. 1, 1955. Decl. Mar. 30, 1960. 4p. Contract [W-31-109-Eng-52]. OTS.

A decrease of 27% in bend strength of alundum was observed after immersion in Redox Process solutions for periods of 1 to 4 weeks. No significant changes in impact strength were found. (C.W.H.)

16995 HW-44585

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

CRYSTALLITE SIZES OF  $\text{PuO}_2$  POWDERS. P. G. Pailmer. July 27, 1956. Decl. Mar. 7, 1960. 5p. Contract [W-31-109-Eng-52]. OTS.

Samples of  $\text{PuO}_2$  were examined by x-ray diffraction for crystallite size and perfection. The  $\text{PuO}_2$  was formed by thermal decomposition of the oxalate. Measurement of the integral widths of diffraction lines gave values of broadening which were used to calculate the effective crystallite thickness. (J.R.D.)

16996 HW-60556

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

PORLTAND CEMENT GROUT VAPOR PRESSURE - TEMPERATURE TEST. H. W. Stivers. June 1, 1959. 12p. OTS.

A test was made to determine if vapor pressure could be developed from the vaporization of moisture contained in the Portland cement grout upon heating. Portland cement grout when sufficiently sealed within a container produced an indicated pressure even in excess of that defined by the steam tables for an indicated saturation temperature. (W.L.H.)

16997 IS-125

Ames Lab., Ames, Iowa.

CREEP OF TANTALUM UNDER CYCLIC ELEVATED TEMPERATURES. Robert L. Hammel and Robert E. Uhrig. Apr. 1960. 62p. Contract W-7405-eng-82. OTS.

An initial study was conducted on the effects of cyclic temperature variations of small amplitudes upon the creep properties of tantalum. The results show a marked weakening of the material when a temperature variation of a few degrees is applied in a sinusoidal manner at a rate of one cycle per hour. Application of a temperature compensated time parameter for the prediction of the cyclic temperature curves is inadequate to explain the observed increase in creep rate. With vacuum arc-cast tantalum, possessing high initial cold work, relief of the residual cold work strain appears to contribute to the acceleration of the strain rate as evidenced by a reduction in hardness after the cyclic temperature application. (auth)

16998 KAPL-M-WAO-7

Knolls Atomic Power Lab., Schenectady, N. Y.

THE HOT DUCTILITY OF INCONEL BP-85 WELD DEPOSITS. W. A. Owczarski. Apr. 1960. 22p. Contract W-31-109-Eng-52. OTS.

In order to evaluate the fissure tendency of a covered Inconel BP-85 welding electrode, the ductility of weld deposits from this electrode was studied at high temperatures. The results indicate that Inconel BP-85 welds have good hot ductility but lose their ductility completely at 2150°F, while wrought Inconel keeps its ductility up to 2400°F. (D.L.C.)

16999 NAA-SR-5015

Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.

THE ZIRCONIUM-HYDROGEN SYSTEM AT HIGH HYDROGEN CONTENTS. G. G. Libowitz. June 30, 1960. 26p. Contract AT-11-1-GEN-8. OTS.

In order to elucidate the phase diagram of the Zr-H system at high hydrogen contents, a pressure-composition-temperature study of this system in the temperature range 550 to 850°C was carried out from ZrH to ZrH<sub>2</sub>. From the obtained isotherms, the position of the boundary between the two-phase ( $\beta + \delta$ ) region and the single phase  $\delta$  region was more precisely defined (where  $\beta$  designates the hydrogen stabilized high temperature zirconium phase, and  $\delta$  the cubic hydride phase). The isotherms also show no evidence of a two-phase hydride region (cubic + tetragonal hydrides coexisting) in this temperature range, as has been observed at room temperature. (auth)

17000 NMI-9214

Nuclear Metals, Inc., Concord, Mass.

REFRACTORY METAL PHASE DIAGRAMS. Quarterly Progress Report for the Period July 15, 1959 to October 15, 1959. E. J. Rappoport. Dec. 18, 1959. 21p. Contract AF33(616)-6023.

A summary of activities in a program to determine the phase diagrams of alloys such as Ta-Ru, Ta-Os, Ru-W,

Nb-Re, Hf-W, Hf-Mo, Os-W, and Hf-Re is presented. (J.R.D.)

17001 PB-161093

National Bureau of Standards. Cryogenic Engineering Lab., Boulder, Colo.

CRYOGENIC MATERIALS DATA HANDBOOK. [195?]. 22p. Contract AF04(647)-59-3. OTS.

Data on the physical properties of Al, Co, Cu, Fe, Ni, Ti, carbides, non-metals, Be, and Mo over the temperature range -423 to +500°F are included. (W.L.H.)

17002 SC-4415(RR)

Sandia Corp., Albuquerque, N. Mex.

THE DIMENSIONAL PROPERTIES OF MOLDED SILICONE RUBBERS RELATED TO O-RING DESIGN. George W. Dyckes. Apr. 1960. 16p. OTS.

The dimensional properties of silicone rubber were investigated. Shrinkage values were determined for a number of silicone materials using simulated O-ring sections. The relation of shrinkage values to specimen size and dimensional variance was studied and a guide for establishing O-ring tolerances was proposed. The dimensional stability of all materials was checked over a six-month period. (auth)

17003 TID-5982

Metal Hydrides, Inc. Chemical Research Lab., Beverly, Mass.

LETTER REPORT NO. 14 UNDER AEC CONTRACT AT(30-1)-2298. David W. Rudd. June 2, 1960. 10p. OTS.

Data for the rate of hydrogen permeation through nickel with 0, 2, and 4% copper added, at 640 to 800°C and 1.1 to 2 atm pressure are given. The system of nickel with 1% copper developed a high-temperature leak and had to be dismantled. Graphs plotted with this data are also included. (M.C.G.)

17004 TID-6038

Pittsburgh. Univ.

THERMAL AND STRUCTURAL STUDIES OF Ta<sub>2</sub>H, Ta<sub>2</sub>D, MgNi<sub>2</sub>, DyCo<sub>5</sub> AND THE Dy-H, Tb-H, Ho-H, Yb-H AND KCl-KBr SYSTEMS. Annual Report Covering the Period May 15, 1959 to May 15, 1960 [on] APPLICATION OF CHEMICAL THERMODYNAMICS AND RELATED PHENOMENA TO THE STUDY OF ALLOY FORMATION. W. E. Wallace. June 1, 1960. 35p. Contract AT(30-1)-647. OTS.

Susceptibility measurements indicated that MgNi<sub>2</sub> is paramagnetic. The curie point of this compound was not established. Low-temperature specific heat measurements led to a third low entropy for MgNi<sub>2</sub> of 21.20 entropy per mole at 25°C. Calorimetric studies of MgCd<sub>3</sub> and Mg<sub>3</sub>Cd showed that in certain temperature regions, thermal equilibrium is attained only after many hours following a change in the temperature of these materials by a few degrees. Results of investigations on heat capacities and residual entropy of Ta<sub>2</sub>H are presented graphically. A study of the arrangement of deuterium atoms in Ta<sub>2</sub>D led to seemingly contradictory conclusions based on diffraction data, and on the vanishing residual entropy of Ta<sub>2</sub>H. Resolution of these conclusions was made by postulating domain-type structures for  $\beta_1$ -Ta<sub>2</sub>D. Results of investigations on the residual entropy of equimolal KCl-KBr solid solution indicate that the entropies of formation distribution for this solid solution is random. Internal friction effects were investigated in hydrogenated VB metals while the samples were either warming or cooling at about 2°/min. Samples containing less than 15 atomic % hydrogen showed no internal friction peaks which could be ascribed

to dissolved hydrogen. At higher concentration peaks developed, the position and size of which correlated with the hydrogen content. Discussions of work currently in progress are included on constitution of the V-H system, differential thermal analysis of the Ta-H system, studies of the lanthanide-hydrogen system, and heat capacities of DyCo<sub>5</sub>. (J.R.D.)

**17005** WADC-TR-57-150(Pt.I)

Michigan. Univ., Ann Arbor. Engineering Research Inst. EFFECT OF PRIOR CREEP ON MECHANICAL PROPERTIES OF AIRCRAFT STRUCTURAL METALS (2024-T86 ALUMINUM AND 17-7 PH STAINLESS). Period covered: February 10, 1956 to January 9, 1957. Jeremy V. Gluck, Howard R. Voorhees, and James W. Freeman. Feb. 20, 1957. 115p. Project title: MATERIALS ANALYSIS AND EVALUATION TECHNIQUES. Task title: DESIGN DATA FOR METALS. Contract AF33(616)-3368. (AD-150956). OTS.

Tests were performed on two typical aircraft structural sheet alloys in an investigation to study changes in mechanical properties brought about by prior exposure to elevated-temperature creep conditions. Specimens of 2024-T86 aluminum alloy and 17-7PH(TH 1050) precipitation hardening stainless steel were exposed for 10, 50, and 100 hours at stresses giving up to 3% total deformation at 350 to 500°F for the 2024-T86, and 600 to 900°F for the 17-7PH. Following the exposures, short-time tensile, compression, or tension-impact tests were run at either room temperature, the temperature of exposure, or both. The results indicate that the short-time strength of structural materials may be either raised or lowered. The changes in properties may approach as much as 50% of the original value. The direction of the change depends on the material, test temperature, creep exposure conditions, and property being measured. From the standpoint of the structures designer the most important changes found are a large drop in strength for 2024-T86 after prior creep exposure for times of from 10 to 100 hours, and an apparent decline in the room temperature ductility of 17-7PH(TH 1050 condition) after prior creep exposure for 100 hours at temperatures near 600°F. (auth)

**17006** WAL-TR-405.1/1(Suppl.)

Watertown Arsenal Lab., Mass. NOTCH SENSITIVITY IN HIGH STRENGTH SHEET MATERIALS. Progress Report No. 12. G. M. Orner and C. E. Hartbower. May 16, 1960. 14p. (AMC-TR-60-7-662(Suppl.)).

Results of extensive testing indicate that the Charpy method is a simple and economical test for notch sensitivity in high-strength sheet materials provided that the sheet can be embrittled by lowering the temperature and the materials are not less than 40 mils thick. (J.R.D.)

**17007** WAL-TR-831.1/1

Watertown Arsenal Lab., Mass. TEMPERATURE GRADIENT—HARDNESS TECHNIQUE FOR DETERMINATION OF RECRYSTALLIZATION OF TEMPERATURE. Joseph M. Dhosia and Marvin B. Pierson. May 1960. 22p. DA Project No. 5B93-32-003. (PB-161473). OTS.

A technique was developed by which recrystallization temperature of alloys can be determined rapidly and with satisfactory accuracy. A 6 to 7 in. bar of the alloy is heated for a specific time in a specially designed gradient furnace and cooled. A hardness survey is then made along the bar and this is cross-plotted against the temperature gradient to which it had been subjected. The temperature at that point of the bar where hardness values fall off abruptly

is then designated as the recrystallization temperature. (auth)

**17008** WAPD-SFR-Fs-173

Westinghouse Electric Corp. Bettis Plant, Pittsburgh. OUTLINE OF ALTERNATE CONTROL MATERIAL INFORMATION OBTAINED AT BETTIS PLANT. July 2, 1956. Decl. Mar. 30, 1960. 102p. OTS.

A summary of experimental data obtained during the period January 1 to June 15, 1956, as part of a Bettis Plant investigation of control materials for nuclear reactors is given. No attempt is made to interpret, evaluate, or discuss the data. (auth)

**17009** WCAP-1580

Westinghouse Electric Corp. Atomic Power Dept., Pittsburgh.

THERMOELECTRIC NUCLEAR FUEL ELEMENT PROGRESS REPORT NO. 23. G. R. Kilp, W. P. Blankenship, R. C. Goodspeed, R. A. Markley, and P. V. Mitchell. June 10, 1960. 27p. Contract AT(30-3)-500. OTS.

A 200 channel digital voltmeter was placed in operation. Swaged couples of P- and N-type PbTe were prepared. A Li<sub>0.06</sub> Ni<sub>0.94</sub>O sample irradiated at 400°C exhibited little radiation effects. A sample of P-type PbTe, irradiated at 375°C, exhibited a slight increase in Seebeck coefficient and a doubling of the value of the electrical resistivity. The cold pressing characteristics of N- and P-type PbTe powders, and heat treating characteristics of the N-type, were studied. Swaging trials on N- and P-type PbTe at 20 and <300°C showed a temperature effect on uniformity of thickness of clad and core rod. A die was designed for pressing annular pellets of thermoelectric materials. (For preceding period see WCAP-1565.) (C.J.G.)

**17010** AEC-tr-4093

MECHANICAL PROPERTIES AND RECRYSTALLIZATION DIAGRAM OF IODIDE ZIRCONIUM. E. M. Savitskii and V. F. Terekhova. Translated by Lydia Vinters (Argonne National Lab.) from Trudy Inst. Met. im. A. A. Baikova, No. 3, 181-90(1958). 14p. JCL or LC.

The effect of temperature (-195 to 1200°C) on the mechanical properties of iodide zirconium revealed that the hexagonal  $\alpha$ -zirconium has significant ductility at -196°C.  $\beta$ -Zirconium with a body-centered cubic lattice exhibited a higher ductility than  $\alpha$ -zirconium. The  $\alpha \Rightarrow \beta$  polymorphous transition in zirconium was characterized by a break in the shape of the temperature curve for mechanical properties. The dependence of grain size and degree of deformation in cold rolling on the annealing temperature were investigated. The recrystallization diagram is presented. The optimum temperature range for annealing the cold-deformed iodide zirconium was determined to be 700 to 750°C. (C.J.G.)

**17011** AERE-Trans-852

INVESTIGATION OF RELAXATION AND RECRYSTALLIZATION IN REFRACOTRY CARBIDES OF TITANIUM AND TUNGSTEN. S. S. Gorelik, E. I. Mozzhukhin, and Z. Maier. Translated by R. Hardbottle from Izvest. Vyschikh Ucheb. Zavedenii, Tsvetnaya Met., No. 2, 153-60 (1958). 15p.

The relaxation and recrystallization in refractory carbides of titanium and tungsten were studied by use of surface cold hardening and by examination of the structural transformations occurring in the hardened surface layer during heating. (J.R.D.)

**17012**

THERMAL PROPERTIES OF SIX GLASSES AND TWO GRAPHITES. C. F. Lucks, H. W. Deem, and W. D. Wood

( Battelle Memorial Inst., Columbus, Ohio). Am. Ceram. Soc. Bull. 39, 313-19(1960) June.

Thermal-conductivity, linear-thermal-expansion, specific-heat, and density values are reported for the following materials: white (clear) plate glass, Pyrex No. 774, Solex 2808X, Solex "S," Grades 7087 and GBH graphite, fused silica, and Vycor. Calculated values of the thermal diffusivity are reported for all of the above materials except the Grades 7087 and GBH graphite. The temperature range covered is, in general, from -250° to about 1000°F. The upper temperature for both graphites was extended to 3000°F for the thermal expansion and specific heat measurements, and to 1800°F for the thermal conductivities. (auth)

### 17013

RESEARCH IN THE  $ZrO_2$ - $TiO_2$ - $SiO_2$  SYSTEM. A. Cocco and N. Schromek (Università, Trieste, Italy). Chim. Ind. (Milan) 42, 480-3(1960) May. (In Italian)

The influence is examined of small percentages of  $SiO_2$  at high temperature (1650°C) on the phase relations between  $TiO_2$ - $ZrO_2$ . The equilibrium isotherm of the ternary system is examined. Experimental results of reflection microscopy and x-ray examinations show that small amounts of  $SiO_2$  form—at 1650°C—with  $TiO_2$  and  $ZrO_2$  a fused mass (5 to 10% of the total mass) without altering substantially the phase relations existing between  $TiO_2$  and  $ZrO_2$ . The study of the ternary system at 1400°C shows the presence of a binary equilibrium line, of three zones in which exist two phases, and of three zones in which three phases are present. The graph of the probable isotherm of the ternary system, at 1400°C, is given. (auth)

### 17014

DIFFUSION OF SOME METALS IN DILUTE SOLUTION IN URANIUM. Michel Moosé, Viviane Lévy, and Yves Adda. Compt. rend. 250, 3171-3(1960) May 9. (In French)

From experiments made on heterogeneous systems, the diffusion of iron, nickel, chromium, and silicon in uranium was studied. By comparing the diffusion constants determined in this study with those obtained in previous investigations, it is shown that the diffusion constant decreases when the atomic radius of the solute increases. (tr-auth)

### 17015

X-RAY STUDY OF LINEAR COMPRESSION OF GRAPHITE AT PRESSURES UP TO 16000 kg/cm<sup>2</sup>. S. S. Kabalkina and L. F. Vereshchagin (Inst. of Physics of High Pressures, Academy of Sciences, USSR). Doklady Akad. Nauk S.S.R. 131, 300-2(1960) Mar. 11. (In Russian)

An x-ray-diffraction analysis of linear compression in prepared, spectrally pure graphite and Ceylon graphite at pressures to 16000 kg/cm<sup>2</sup> shows that they have identical linear compression  $k_{11}$ . The volume compression of graphite is determined by the linear  $k_{11}$  as a result of weak Van der Waals interactions between layers. The Van der Waals radius for hydrogen atoms at high compression,  $P = 15000$  kg/cm<sup>2</sup>, is  $R_c = 1.63$  Å and with  $P = 1$  kg/cm<sup>2</sup>,  $R_c = 1.68$  Å. Thus, under high pressure  $R_c$  reduces to a lesser degree than the corresponding Van der Waals radius. (R.V.J.)

### 17016

SIGMA-PHASE IN THE RHENIUM-VANADIUM SYSTEM. M. A. Tylkina, K. B. Povarova, and E. M. Savitskii (Baikov Inst. of Metallurgy, Academy of Sciences, USSR). Doklady Akad. Nauk S.S.R. 131, 332-4(1960) Mar. 11. (In Russian)

The temperature interval of the  $\sigma$  phase in rhenium-vanadium alloy was determined at 1750°C for 7 hours, 1500°C for 5 hours, and 1000°C for 450 hours. The x-ray-

diffraction and microstructure analyses indicate eutectic disintegration of the alloy at 1500°C and formation of two solid solution mixtures:  $\alpha$  with vanadium base and  $\beta$  with rhenium base. The x-ray picture for the cast alloy shows lines characteristic of  $\sigma$  phase with lattice parameters  $a = 9.36$  Å,  $C = 4.86$  Å,  $c/a = 0.52$ . Correlated data for  $\sigma$  phases of rhenium with zirconium, vanadium, niobium, tantalum, chromium, molybdenum, tungsten, manganese, and iron are tabulated. The  $\sigma$  phase of Re-Zr alloy is an exception, being similar to the  $\sigma$  phase of the Mendeleev groups with inherent  $\sigma$  phase, while for the other metals of subgroup IVA the formation of  $\sigma$  phase is not inherent. (R.V.J.)

### 17017

ELECTRON DIFFRACTION STUDY OF BORON OXIDE ( $B_2O_3$ ) MOLECULE STRUCTURE. P. A. Akishin and V. P. Spiridonov (Lomonosov Moscow State Univ.). Doklady Akad. Nauk S.S.R. 131, 557-60(1960) Mar. 21. (In Russian)

Electron-diffraction analysis of the configuration and geometric parameters of gaseous  $B_2O_3$  molecules was made with a device designed for analyzing nonvolatile compounds in a high-temperature evaporator (with electron bombardment heating). Boron oxides prepared by continuous dehydration in a vacuum were evaporated at 1500 to 1800°C in molybdenum and tungsten ampoules. Seven series of electrograms suitable for photometric and visual studies were analyzed. The obtained electronographic data indicated a plane angular model with linearly distributed bonds and parameters. (R.V.J.)

### 17018

STRUCTURE AND PROPERTIES OF RARE-EARTH AND YTTRIUM HARD METALS. Ira Binder (Union Carbide Research Inst., Tuxedo, N. Y.). J. Am. Ceram. Soc. 43, 287-92(1960) June.

A review is presented on several types of compounds of rare earths and yttrium. The preparation, structures, and properties are given for the borides and silicides. Carbides, nitrides, and sulfides are reviewed briefly. (D.L.C.)

### 17019

EXCITATION PROCESSES IN CERAMICS AND ANOMALOUS INCREASE IN THERMAL CONDUCTIVITY AT ELEVATED TEMPERATURES. D. H. Whitmore (Northwestern Univ., Evanston, Ill.). J. Appl. Phys. 31, 1109-12(1960) June.

The problem of the anomalous increase in the observed thermal conductivity of single-phase ceramics at high temperatures is considered. At temperatures above the onset of this anomalous rise, account is taken of the possibility that phonon, electronic, and radiative heat transfer, as well as transport of thermal energy by electron-hole pairs, excitons, and dissociated gas molecules, may operate simultaneously and individually contribute significantly to the total heat flow. On the basis of reliable conductivity data on nonporous monocrystals of single-phase ceramics, estimations are made of the magnitudes of these high-temperature components which reveal that excited states of low excitation energy may occur in certain ceramics. In these instances, such excited energy-carrying states are able to diffuse down the temperature gradient in the specimen thereby producing a non-negligible contribution to its observed thermal conductivity. (auth)

### 17020

TENSILE STRENGTH OF PYROLYTIC GRAPHITE UP TO 2750°C. H. E. Martens and L. D. Jaffe (California Inst. of Tech., Pasadena). J. Appl. Phys. 31, 1122(1960) June.

The polycrystalline material was deposited on a syn-

thetic graphite substrate by decomposition of a methane-hydrogen mixture at 2100°C; its specific gravity prior to tensile testing was 2.20. Stress was applied parallel to the plane of deposition. At 2750°C, only minimum strength values were obtained. These data indicate no maximum in the strength-temperature curve. Other graphite seems to increase in strength as the temperature is increased to 2750°C, or higher. (B.O.G.)

## 17021

EFFECT OF APPLYING A MAGNETIC FIELD DURING NEUTRON IRRADIATION ON THE MAGNETIC PROPERTIES OF Fe-Ni ALLOYS. A. I. Schindler and E. I. Salkovitz (U. S. Naval Research Lab., Washington, D. C.). *J. Appl. Phys.* 31, Suppl. to No. 5, 245S-6S(1960) May.

To test the similarity between thermally induced ordering and irradiation induced ordering, a series of commercial Fe-Ni samples were irradiated in the presence of a saturating magnetic field. Square hysteresis loops were found for all the samples irradiated in this manner. Such results are consistent with the proposal that directional short range ordering and consequent uniaxial anisotropy were created by the neutron irradiation. (auth)

## 17022

MAGNETIC PROPERTIES OF URANIUM DIGERMANYDE. Clayton E. Olsen (Los Alamos Scientific Lab., N. Mex.). *J. Appl. Phys.* 31, Suppl. to No. 5, 340S-1S(1960) May.

Investigations on the magnetic properties of actinide element intermetallic compounds have disclosed that  $UGe_2$  and  $PuGe_2$  are ferromagnetic with magnetic moments greater than 0.803 and 0.144 Bohr magneton per molecule, respectively, at 4°K. Electrical resistivity measurements on  $UGe_2$  indicate an interaction of the conduction electrons with the local spin which produces ferromagnetism. Also the electrical resistivity of  $USi_2$ , which is not ferromagnetic, was measured for comparison. (auth)

## 17023

A STUDY OF THE SOLUTION RATE OF IRON IN LIQUID BISMUTH FROM A NUMBER OF FERRITIC STEELS. L. W. Graham and G. W. Wilson (Hawker-Siddeley Nuclear Power Co., Ltd., Manchester, Lancs, Eng.). *J. Brit. Nuclear Energy Conf.* 5, 128-32(1960) Apr.

A series of experiments measuring the rate of solution of iron from five ferritic steels in liquid bismuth at 550°C is described together with an investigation of the effect on this solution rate of 200 ppm of zirconium added to the liquid metal. Mechanisms explaining the reduction in the solution rate observed with increasing chromium content of the steels and also the decrease in solution rate and apparent solubility in bismuth containing zirconium are proposed. In the former case the solution rate appears to be governed by the rate of passage of solute atoms across the solid/liquid interface. The effects of the zirconium appear to be consistent with either a reduction in the actual solubility of iron in a bismuth-zirconium solution or the formation of a compound layer on the steel surface. (auth)

## 17024

THERMAL DECOMPOSITION OF NIOBIUM AND TANTALUM MONOCARBIDES. Charles P. Kempfer and M. R. Nadler (Los Alamos Scientific Lab., N. Mex.). *J. Chem. Phys.* 32, 1477-81(1960) May.

The thermal decomposition of polycrystalline NbC was investigated from 2000 to 3200°C, and TaC from 1890 to 3320°C in the presence of one atmosphere of helium. It was found that both compounds lose carbon preferentially, and that the final carbon/metal molar ratio obtained may be represented by an equation of the form  $C/M = A - B \exp(\lambda t)$ , where  $t$  is the maximum temperature of heating for a constant time (30 min in both cases). Similarly the resultant lattice constant may be expressed as  $a_0 = A' - B' \exp(\lambda' t)$ , where  $a_0$  is in angstroms at 25°C. For a maximum temperature of 3000°C and heating times of 30 min to 12 hr,  $a_0 = 4.459084 + 0.0093071 \exp(-0.18916 \tau)$  for NbC, where  $\tau$  is the time in hours. It was found that  $a_0 = 4.414712 + 0.056862 (C/Nb)$  for the C/Nb range 0.885 to 0.981 and that  $a_0 = 4.385779 + 0.070204 (C/Ta)$  for the C/Ta range 0.906 to 0.996. By extrapolation, the lattice constants of stoichiometric NbC and TaC should be  $4.47157 \pm 0.00012$  Å at 25°C and  $4.45598 \pm 0.00038$  Å at 25°C, respectively. (auth)

## 17025

POLARIZED OCTAHEDRA IN BARIUM TETRATITANATE. David H. Templeton and Carol H. Dauben (Univ. of California, Berkeley). *J. Chem. Phys.* 32, 1515-18(1960) May.

Single-crystal x-ray-diffraction studies show that  $BaTi_4O_9$  is orthorhombic, space group Pmmn, with  $a = 14.53 \pm 0.02$ ,  $b = 3.79 \pm 0.01$ , and  $c = 6.29 \pm 0.01$  Å, with two formula units per unit cell and calculated density  $4.54 \text{ g cm}^{-3}$ . Each barium atom has four oxygen neighbors at 2.81 Å, two at 2.96, and four at 3.09, at the corners of a pentagonal prism. Titanium atoms are in distorted octahedra of oxygen atoms. The Ti-O distances range from 1.77 to 2.32 Å, with standard deviations of 0.03 Å or less. Titanium atoms occur at points 0.30 and 0.21 Å from the centers of gravity of the oxygen atoms of the two kinds of octahedra. This polarization of the two octahedra is similar to or greater in magnitude than that observed in the ferroelectric phases of  $BaTiO_3$  and  $PbTiO_3$ . (auth)

## 17026

A NEW METHOD OF STUDYING THE SUBLIMATION PROCESSES IN METALS. Yu. (J.) V. Kornev and S. L. Zubkovskii (Zubkovskij). *Kernenergie* 1, 124-7(1958) Feo. (In German)

A radioisotope technique for determining the heat of sublimation of metals is presented. It allows continuous measurement of the effusion rate of a saturated vapor from a small opening. The radioisotope is alloyed with the metal and the equilibrium distribution controlled by autoradiography. The effusion rate of the saturated vapor flowing through the small opening into a vacuum is determined by the increase of radioactivity of a collecting disk measured by a counting tube behind the disk. The method allows continuous control of the evaporation and condensation at the collecting disk and is also useful for studying diffusion in metals and alloys. (tr-auth)

## 17027

TENSILE BEHAVIOUR OF PYROLYTIC GRAPHITE AT 2,750°C. H. E. Martens and W. V. Kotlensky (California Inst. of Tech., Pasadena). *Nature* 186, 960-2(1960) June 18.

Engineering stress-strain curves were obtained at temperatures of 1,650 to 2,750°C for a pyrolytic graphite which had been heated to 2,870°C. Changes were observed in the crystal structure as determined by x-ray diffraction. Results are illustrated graphically. Changes in the microstructure caused by the heating and straining were also observed and are illustrated photographically. Data on the tensile properties of pyrolytic graphite are tabulated. (C.H.)

## 17028

URANIUM CARBIDE—PRODUCTION AND PROPERTIES. A. Accary and P. Blum (Commissariat à l'Énergie Atomique, Saclay, France). *Nuclear Power* 5, No. 50, 122-3(1960) June.

The following methods for the preparation of UC were tried in France (Saclay): (1) U-graphite reaction, (2) U-hydrocarbon(gas) reaction, and (3) reduction of  $UO_2$  by carbon. The method finally selected for fairly large-scale production of cast UC is sintering a mixture of carbon and U powders. U is produced by Ca reduction of  $UO_2$ , and then sintered with carbon either at high temperatures (thermal sintering) or simply by hot pressing. Hot pressing, while still not suitable for production of UC rods or slugs, gives chemical stability superior to that produced by thermal sintering. The products have fine grain size, random grain orientation, and absence of dicarbide as compared to cast U-C alloys. The production of UC in France is sufficient to supply fuel loads for new reactors to replace  $UO_2$  fuel. Some of the properties of UC prepared as above are given. (D.L.C.)

## 17029

POINT DEFECTS IN PLATINUM. G. R. Piercy (Atomic Energy of Canada Ltd., Chalk River, Ont.). Phil Mag. (8) 5, 201-21(1960) Mar.

An investigation was made of the mobility and types of point defects introduced in platinum by deformation in liquid nitrogen, quenching into water from 1600°C, or reactor irradiation at 50°C. In all cases the activation energy for motion of the defect was determined from measurements of electrical resistivity. Measurements of density, hardness, and x-ray line broadening were made where applicable. These experiments indicated that the principal defects remaining in platinum after irradiation were single vacant lattice sites and after quenching were pairs of vacant lattice sites. Those present after deformation in liquid nitrogen were single vacant lattice sites and another type of defect, perhaps interstitial atoms. (auth)

## 17030

ELECTRICAL PROPERTIES OF CRYSTAL COMPOUNDS OF GRAPHITE. I. CONDUCTANCE OF GRAPHITE/BROMINE. L. C. F. Blackman, J. F. Mathews, and A. R. Ubbelohde (Imperial Coll. of Science and Tech., London). Proc. Roy. Soc. (London) A256, 15-27(1960) May 31.

Measurements are reported of the electrical resistance of graphite/bromine of various compositions. Some of the experiments refer to natural graphite, but the majority deal with specimens of pyrolytic graphite which show good orientation with respect to both a- and c-axes. Changes of resistance in these two directions were measured as a function of bromine uptake to limiting concentrations; cyclic sorption—desorption studies were included where appropriate. Results are discussed in the light of current theories about the electron band structure in graphite and in relation to the nature of the bonding between bromine and graphite. (auth)

## 17031

A STUDY OF GRAIN SHAPE IN CEMENTED TITANIUM CARBIDES. Thomas J. Whalen and Michael Humenik, Jr. (Ford Motor Co., Dearborn, Mich.). Trans. Met. Soc. AIME 218, 401-4(1960) June.

The grain shape of the carbide in nickel-bonded and cobalt-bonded titanium carbides was studied by micrographic examination, and the influence of sintering atmosphere, sintering substrate, and the amount of metal binder on the grain shape was determined. It was found that the carbide grain cross sections in the nickel and cobalt cermets ranged from round to angular, depending on the sintering conditions. The spheroidization of the carbides in both cobalt-bonded and nickel-bonded titanium carbides may be attributed to oxygen. (auth)

## 17032

HIGH CONDUCTIVITY COPPER-RICH Cu-Zr ALLOYS. Matti J. Saarivirta (Amco Research and Development, Inc., Carteret, N. J.). Trans. Met. Soc., AIME 218, 431-7(1960) June.

A high-purity Cu-Zr alloy system was investigated. The Zr content of the alloys studied varied from 0.003 to 0.23%. The solid solubility of Zr in Cu and some physical and mechanical properties of the alloys were determined. By proper heat treatment, Cu-Zr alloy can develop a high electrical conductivity and resistance to softening at temperatures up to 500°C. This combination of desirable properties makes this alloy superior to other commercial copper base alloys for use in the electrical conductor field. (auth)

## 17033

AN EXTRUDED CHROMIUM-ALUMINA ALLOY. A. Gatti (General Electric Lab., Schenectady, N. Y.). Trans. Met. Soc. AIME 218, 437-9(1960) June.

A dispersion of  $Al_2O_3$  was produced within Cr by the hydrogen reduction of a solid solution of  $Cr_2O_3-Al_2O_3$ . The resulting powder was compacted, extruded, and the material tested in tension at various temperatures and in creep at 1800°F. The material is ductile above 1200°F and is at least twice as strong as electrolytic chromium at all temperatures. Its creep resistance, rupture strength, and ductility at 1800°F warrant further work to improve its low-temperature properties. (auth)

## 17034

DIFFUSION STUDIES IN THE URANIUM-NIOBIUM (COLUMBIUM) SYSTEM. Norman L. Peterson and Robert E. Ogilvie (Massachusetts Inst. of Tech., Cambridge). Trans. Met. Soc. AIME 218, 439-44(1960) June.

Interdiffusion and intrinsic diffusion coefficients were determined in the U-Nb system from diffusion couples analyzed with an electron microbeam probe. A previously unreported intermediate phase, designated as the delta phase, was found to exist along the Nb-rich side of the miscibility gap. Its composition width was determined from the concentration gradients in the diffusion couples. The presence of this phase was confirmed by microhardness analysis and metallographic observations. (auth)

## 17035

PRECIPITATION PROCESSES IN Mg-Th-Zr ALLOYS. L. Starkey (Dow Chemical Co., Midland, Mich.). Trans. Met. Soc. AIME 218, 466-72(1960) June.

Quantitative x-ray-diffraction studies of the precipitation of Th in a Mg-3.3 Th-0.51 Zr alloy (HK31A) in both the as-cast and cold-worked states show that the precipitation may be described by  $f = 1 - e^{-(t/\tau)^{1/2}}$  over most of the aging period. The effects of cold work and temperature changes are determined. The precipitation of the equilibrium Mg-Th compound is preceded by the formation of a transition phase of higher Th content, with the composition  $Mg_2Th$  and with a Laves-phase structure. (auth)

## 17036

USE OF AXIS DISTRIBUTION CHARTS TO REPRESENT SHEET TEXTURES. C. J. McHargue and L. K. Jetter (Oak Ridge National Lab., Tenn.). Trans. Met. Soc. AIME 218, 550-3(1960) June.

The use of axis charts for representing the texture of cold-rolled thorium sheet was compared with conventional pole figures. Four texture components were deduced from the axis charts and shown to be consistent with the pole figures. It was shown that consideration of the pole figures alone could lead to an apparent component which is the

average of two actually present. It was shown that the spread about the "ideal" textures and the amount of material associated with each could be readily obtained from the axis chart method. (auth)

17037

DEFEKTOSKOPIIA METALLOV. SBORNIK STATEI. (Defectoscopy of Metals. Symposium). D. S. Shraiber, ed. Moscow, State Publishing House of Defense Industry, 1959. 459p.

Papers are included on various methods of metal quality control and new apparatus and devices used in industry for detecting defects in metals. The data were gathered from research carried out by native and foreign laboratories and plants. Non-destructive methods of control such as x- and  $\gamma$ -ray analyses and ultrasonic and magnetic methods are discussed as well as less used electromagnetic, luminescence, and thermoelectric methods. The book is designed for engineers and technical personnel interested in quality control. (R.V.J.)

## Radiation Effects

17038 APAE-61

Alco Products, Inc., Schenectady, N. Y.

A SURVEY OF THE EFFECTS OF NEUTRON IRRADIATION ON THE IMPACT AND OTHER MECHANICAL PROPERTIES OF PRESSURE VESSEL STEELS FOR THE SM-2 REACTOR. Richard William Kelleman. Apr. 1, 1960. 77p. Contract AT(30-3)-326. OTS.

A literature survey on the effects of neutron irradiation on impact and other mechanical properties of both ferritic steels and austenitic stainless steels is presented. The materials studied included carbon and low alloy steels such as: ASTM A-212B, ASTM A-201, ASTM A-301B (CR-Mo), ASTM A-106 (coarse and fine grained), ASTM A-285, ASTM A-302B (Mn-Mo), ASTM A-353, ASTM A-203, Grade D, E-7016 carbon steel weld metal, USS Carilloy T-1, HY-65, and HY-80. Types 304 and 347 stainless steels were investigated as representative austenitic materials which might be used in pressure vessel construction. An evaluation was made of the irradiation induced changes in the mechanical properties of the above materials. The ferritic steels were evaluated primarily on the basis of increases in transition temperature due to irradiation and decreases in the amount of maximum energy absorbed prior to ductile failure. Factors such as industrial experience, changes in other mechanical properties, and the susceptibility of these materials to temper embrittlement were considered. Austenitic stainless steels were evaluated on the basis of post-irradiation and low temperature impact strength and on irradiation induced changes in other mechanical properties. It is concluded that austenitic stainless steels are capable of resisting harmful property damage at integrated neutron fluxes  $> 1$  Mev of at least  $1$  to  $2 \times 10^{21}$  nvt. Most carbon or low alloy steels with the exception of ASTM A-212B, were subject to severe property damage at exposures in excess of  $1 \times 10^{19}$  nvt. With the application of special reactor operating procedures, it was determined that ASTM A-212B will be satisfactory at integrated neutron fluxes up to  $5 \times 10^{19}$  nvt. (auth)

17039 CRFD-897

Atomic Energy of Canada Ltd. Chalk River Project, Chalk River, Ont.

BEHAVIOR OF URANIUM OXIDE SPECIMENS SHEATHED IN ZIRCALOY-2 AND IRRADIATED IN A PRESSURIZED-WATER LOOP IN THE NRX REACTOR (TEST EEC-8). A. S. Bain. Feb. 1960. 27p. (UKE-CR-1204; AECL-983). AECL.

Various types of  $\text{UO}_2$  and  $\text{ThO}_2-\text{UO}_2$  specimens, sheathed in Zircaloy-2 were irradiated to a burnup of 3850 Mwd/tonne at a position of maximum flux. Aspects of dimensional stability, fission-gas release, and grain growth are discussed. (auth)

17040 CRRP-761-C

Atomic Energy of Canada Ltd., Chalk River, Ont.

ANALYSIS OF MEASUREMENTS OF THE REACTIVITY CHANGE WITH IRRADIATION FOR NATURAL URANIUM SAMPLES. A. G. Ward and D. S. Craig. Apr. 1960. 70p. (AECL-814). AECL.

The experimental measurements and the interpretation of the changes in the reactivity and constituents of natural uranium occurring in irradiations up to 0.63 n/kilobarn are described. The effect of poisons with a short half life, such as  $\text{Xe}^{135}$ , is not included. The measured changes with irradiation of reactivity and constituents of natural uranium are compared with the calculated values. (auth)

17041 DEGIS-149(R)

United Kingdom Atomic Energy Authority. Development and Engineering Group. Library and Information Dept., Risley, Lancs, England.

BIBLIOGRAPHY ON EFFECTS OF RADIATION ON LUBRICANTS. G. I. Maughan and E. Chaffin, comps. Mar. 21, 1960. 11p. BIS.

A selected list of literature references to radiation effects on lubricants, and to radioresistant lubricant development is presented. Sources searched were Nuclear Science Abstracts 1947 to 1959, Engineering Index 1956 to 1958, and Applied Science and Technology Index 1959. (J.R.D.)

17042 HW-33516

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

TENSILE TEST OF IRRADIATED 63-S ALUMINUM FROM PT-105-501-M. D. P. O'Keefe. Oct. 23, 1954. Decl. May 3, 1960. 3p. Contract [W-31-109-Eng-52]. OTS.

Ultimate strength values were obtained on unirradiated and irradiated 63-S aluminum samples having the preirradiation heat treatments T4 (solution heat treated), T6 (solution heat treated and precipitation hardened), and T6 + 100 (solution heat treated, precipitation hardened and overaged 100 hours). The irradiated T4 specimens had an average ultimate strength of 35,900 psi, an increase of 33% over that obtained on unirradiated T4 samples; irradiated T6 averaged 31,000 psi, an increase of 7% over unirradiated samples of the same heat treatment; irradiated T6 + 100 averaged 30,600 psi ultimate, an increase of 5% over unirradiated T6 + 100. No change in the microstructure of the samples from any of the temper groupings could be detected. (auth)

17043 NAA-SR-3888

Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.

ENGINEERING EVALUATION OF A MIXED ALLOY FUEL ELEMENT IRRADIATED AT ELEVATED TEMPERATURES IN THE SRE. J. L. Ballif, B. R. Hayward, and J. W. Walter. June 1, 1960. 84p. Contract AT-11-1-GEN-8. OTS.

A fuel material evaluation was made by destructively examining a full-scale experimental fuel element, irradiated in the SRE to a maximum of 850 Mwd/MTU. The fuel element contained beta-quenched 2.78% enriched unalloyed uranium, in both the cast and rolled forms; powder compacted U-1.2 wt.% Mo; cast U-1.5 wt.% Mo; cast U-2 wt.% Zr; and wrought Th-5.4 wt.% U (5% enriched). The Th-U alloy and the U-1.5

wt.% Mo alloy appeared to be promising fuels, and merit further work. The other U-Mo and U-Zr alloys, and the unalloyed uranium, in both the cast and wrought conditions, showed definite limitations. No significant difference in performance was noted between standard fuel slugs and slugs with intentionally included fabrication defects. Limited metallography, in both the pre- and postirradiation conditions, failed to show any significant radiation effect, except for the appearance of voids in the U-2 wt.% Zr. (auth)

**17044** NP-8764

Battelle Memorial Inst. Radiation Effects Information Center, Columbus, Ohio.

MONTHLY ACCESSION LIST NO. 34 [ON RADIATION EFFECTS DATA]. Apr. 15, 1960. 37p. Project No. 2133. Contract AF33(616)-6564.

**17045** NP-8765

Battelle Memorial Inst. Radiation Effects Information Center, Columbus, Ohio.

MONTHLY ACCESSION LIST NO. 35 [ON RADIATION EFFECTS DATA]. May 15, 1960. 26p. Project No. 2133. Contract AF33(616)-7375.

**17046** TID-5983

Engelhard Industries, Inc., Newark, N. J.

EFFECT OF IRRADIATION OF SOLID CATALYSTS.

Quarterly Progress Report No. 1. H. C. Andersen and P. N. Rylander. Aug. 17, 1959. 15p. Contract AT(30-1)-2402. OTS.

Investigations were made to ascertain in what way, if any, the activity or selectivity of various catalysts may be altered by irradiation. The catalysts used in the study were platinum, palladium, rhodium, ruthenium, and iridium metals in highly dispersed form supported on carriers. For irradiation, a commercial cobalt-60 source was used. Each irradiated catalyst was tested in a number of reactions: liquid phase hydrogenation, hydrogen-oxygen reactions, carbon monoxide oxidation, and nitrous oxide decomposition. (M.C.G.)

**17047** TID-5984

Engelhard Industries, Inc., Newark, N. J.

EFFECT OF IRRADIATION OF SOLID CATALYSTS.

Quarterly Progress Report No. 2. H. C. Andersen and P. N. Rylander. Nov. 25, 1959. 25p. Contract AT(30-1)-2402. OTS.

Since irradiation with cobalt-60 gamma radiation did not result in measurable changes in the catalytic properties of platinum metal catalysts, the effect of more intense radiation was explored. Samples of Pt, Pd, Rh, and Ru were mounted as either powder or pellets with a maximum layer thickness of  $\frac{1}{6}$  in. and exposed to beta radiation. The irradiated catalysts were examined in a number of reactions including the reaction of  $O_2$  and  $H_2$ , oxidation of CO, decomposition of  $N_2O$ , and liquid phase hydrogenation. (M.C.G.)

**17048**

THE STRUCTURES AND PROPERTIES OF SOME METALS AND STEELS AFTER IRRADIATION WITH FAST NEUTRONS. Sh. Sh. Ibragimov, V. S. Lyashenko, and A. I. Zav'yalov. Atomnaya Energ. 8, 413-19(1960) May. (In Russian)

The effects of fast neutron irradiation followed by thermal treatment on the properties of metals were investigated. The alterations in irradiated materials result from defects in crystalline lattices during annealing at certain temperatures. The kinetics and the activation energies

of processes leading to increased strength are determined. (tr-auth)

**17049**

ON THE NEUTRON BOMBARDMENT REDUCTION OF TRANSISTOR CURRENT GAIN. J. W. Easley (Bell Telephone Labs., Inc., Whippoorwill, N. J.) and J. A. Dooley (Wright Air Development Center, Wright-Patterson AFB, Ohio). J. Appl. Phys. 31, 1024-8(1960) June.

Detailed measurements of the fast neutron and gamma bombardment behavior of germanium-alloy-transistor current-gain were obtained concurrent with exposure. These data indicate that previously reported analyses, which lead to a linear dependence of common-base current-gain on fast neutron exposure, yield a good approximation for the npn device, but are not of general validity for the pnp germanium transistor. The extent of departure from the linear approximation depends on the width and conductivity of the base-region and can be appreciable in many cases of practical interest. For the pnp germanium transistor it is necessary to take additional account of both changes during bombardment of the minority-carrier recombination rate at bombardment introduced and initially present recombination centers and changes in the width of the collector junction depletion layer. Observed bombardment curves are in good agreement with an analysis which includes these effects. From initial slopes of the current-gain bombardment curves, values of the product of fast neutron-exposure times minority-carrier-lifetime at bombardment introduced recombination centers are  $9.7 \times 10^7$  for 2.7 ohm-cm p-type and  $14.2 \times 10^7$ ,  $6.0 \times 10^7$ , and  $1.3 \times 10^7$ , for 3.6 ohm-cm, 1.2 ohm-cm, and 0.2 ohm-cm n-type germanium, respectively, in units of sec-neutrons/cm<sup>2</sup>. (auth)

**17050**

EFFECT OF NUCLEAR RADIATION ON ENGINEERING MATERIALS. A. H. Cottrell (Univ. of Cambridge, Eng.). J. Brit. Nuclear Energy Conf. 5, 64-77(1960) Apr.

The importance of radiation damage in materials for use in nuclear power reactors is emphasized and an account is given of various types of radiation damage in such materials. The displacement of atoms by nuclear radiation is briefly discussed and examples are shown of recent electron microscopical photographs of radiation damage in materials. A discussion is given of radiation damage in graphite and the importance of stored energy as a reactor problem. The effect of displaced atoms in producing radiation hardening in metals and radiation embrittlement in structural steels is emphasized and discussed in relation to reactor pressure-vessels. Problems of growth, wrinkling, creep, and inert fission gases in uranium are considered in relation to the life of reactor fuel elements. (auth)

**17051**

RADIATION DAMAGE IN ORGANIC CRYSTALS. II. ELECTRON SPIN RESONANCE OF  $(CO_2H)CH_2CH(CO_2H)$  IN  $\beta$ -SUCCINIC ACID. Chonon Heller and Harden M. McConnell (California Inst. of Tech., Pasadena). J. Chem. Phys. 32, 1535-9(1960) May.

An analysis of the electron spin resonance of  $\alpha$ -irradiated single crystals of  $\beta$ -succinic acid shows that: (a) the principal long-lived paramagnetic species produced by the radiation damage is  $(CO_2H)CH_2CH(CO_2H)$ ; (b) the radical is oriented in the crystal lattice in nearly the same way that the parent succinic acid molecule is oriented in the undamaged lattice; (c) the strongly anisotropic hyperfine interaction due to the  $\sigma$  proton is very

nearly the same as that previously found for the  $\sigma$  proton in the malonic acid radical,  $(\text{CO}_2\text{H})\text{CH}(\text{CO}_2\text{H})$ . In these molecules the  $\sigma$  proton is directly bonded to the carbon atom on which the odd electron is largely localized. The two methylene protons in the radical are not equivalent, and their hyperfine interactions are nearly isotropic, and in the range 80 to 100 Mc. (auth)

## 17052

PROTON MAGNETIC RESONANCE IN IRRADIATED AND UNIRRADIATED POLYVINYL ALCOHOL. Shizuo Fujiwara (Univ. of Electro-Communications, Tokyo). *J. Polymer Sci.* **44**, 93-105(1960) May.

Crystalline and amorphous components in PVA were investigated by the analysis of the line shapes of the NMR spectra of several samples being different in the degree of polymerization and in the forms. Measurements of the temperature dependence of the line shape, the line width, and the second moments were also performed for the irradiated and unirradiated samples. In the samples bombarded in the air by the deuteron beam, marked irradiation effects were observed by the measurements of the humidity dependence of the NMR intensity of the motional component, of the temperature dependences of the line shape and the second moment, and of the behavior of the line shapes at the higher temperature range, suggesting the occurrences of the destruction of the amorphous part, the degradation of the less-motional part, and the cross-linking of the amorphous part with the less-motional one. Investigations were also made with the samples irradiated by gamma rays in vacuum. The NMR features of the gamma-irradiated samples showed the optimum point of about  $10^8$  rad, which would refer to the destruction of the amorphous component and the initiation of cross-linking. (auth)

## 17053

MOLECULAR WEIGHT DISTRIBUTIONS OF VINYL POLYMERS GRAFTED TO A SOLID POLYMERIC SUBSTRATE BY IRRADIATION (THEORETICAL). Joseph Zimmerman (E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.). *J. Polymer Sci.* **44**, 107-16(1960) May.

The molecular weight distributions of vinyl polymers grafted by irradiation were deduced theoretically. The derivations are rigorous for cases where chain transfer is not important or in all cases where the radiation dose is high ( $>1$  Mrad). In the absence of chain transfer, the width of the distribution depends mainly on conversion of monomer to grafted polymer and on the ratio of the rate constant for propagation to that for termination ( $k_p/2k_t$ ). As this ratio gets smaller, the molecular weight distribution becomes broader. For relatively small values of  $k_p/2k_t$  (e.g., 0.5 or less), the width of the distribution increases markedly with increasing conversion. In such cases, the occurrence of chain transfer tends to make the distribution narrower. For a monomer grafted to a substrate where  $k_p/2k_t = 0.9$  (for example), the ratio of weight to number average molecular weight is ca. 2. In general, monomers which have lower rates of propagation should form grafted polymers with broader molecular weight distributions. (auth)

## 17054

SOLID STATE POLYMERIZATION OF ACRYLAMIDE INITIATED BY GAMMA RADIATION. B. Baysal, G. Adler, D. Ballantine, and P. Colombo (Brookhaven National Lab., Upton, N. Y.). *J. Polymer Sci.* **44**, 117-27 (1960) May.

The solid-state polymerization of acrylamide, both in a radiation field and after removal from the field, is shown

to proceed by an unusual kinetic mechanism. The usual steady state assumption is found to be inadequate because there seems to be no free radical termination (in the normal sense) involved. These results are consistent with the view that the solid-state polymerization proceeds by a nucleation mechanism in which the free radicals are probably trapped by overlapping of the reactive sites. (auth)

## 17055

GRAFT COPOLYMERIZATION BY A PREIRRADIATION METHOD. Y. Shinohara and K. Tomioka (Toyo Rayon Co. Ltd., Otsu, Japan). *J. Polymer Sci.* **44**, 195-211(1960) May.

Free radicals as well as peroxides are formed when irradiation of polyethylene is accomplished with the use of cobalt-60 or a Van de Graaff electron accelerator, as radiation sources, even in the presence of air. The free radicals are able to induce graft copolymerization under low temperatures, in which peroxide grafting cannot occur. When the irradiated polymer is stored in air, the trapped free radicals disappear monomolecularly, probably combining with oxygen. The activation energy for this reaction is 20 kcal/mole. In graft copolymerization by free radicals, the per cent grafting is proportional to the square root of the free radical content, and the higher the grafting temperature, the faster the initial rate of graft copolymerization. There occurs a saturation phenomenon of the per cent grafting with a grafting time, especially in high temperatures, and the higher the grafting temperature, the smaller the saturation value. It is believed that the kinetic theory of vinyl polymerization in a homogeneous system is applicable for graft reaction in spite of its apparent heterogeneous character. (auth)

## 17056

HOW FOCUSING COLLISIONS AFFECT RADIATION DAMAGE. Michael W. Thompson (Atomic Energy Research Establishment, Harwell, Berks, Eng.). *Nucleonics* **18**, No. 6, 133; 135-6(1960) June.

Present theories of neutron irradiation damage to metals are inadequate because they neglect the effect of lattices which can focus the colliding particle's momentum along the lines of close packing. When this happens, the irradiation energy is spread out, and damage is less than that from random collisions. This effect is expected to occur if the interatomic distance in the lattice is less than four times the atom radius and the mean free path of the recoiling atom is small compared with interatomic spacing. Thus, the effect will be small in light elements (alkali metals, Be, graphite), may or may not be important in transition metals (Co, Fe, Mn), but is important in "full" metals (Ag, Au, Cu) and heavy elements, especially in  $\alpha$ -uranium. An experiment is reported: a thin Au crystal was irradiated with a proton beam which emerged at 0.3 Mev, and the recoil Au atoms were collected on an Al-coated silica plate. The Au deposit, revealed by radiography, showed that the close-packing 1,1,0 direction influences ejection direction and that the lattice effect is probably in the bulk and not on the surface. When the collector plate was made positive by 120 volts, the pattern spread, indicating that Au is ejected as ions. (D.L.C.)

## 17057

THE HARDENING OF LITHIUM FLUORIDE BY ELECTRON IRRADIATION. A. D. Whapham and M. J. Makin (Atomic Energy Research Establishment, Harwell, Berks, Eng.). *Phil. Mag.* (8) **5**, 237-50(1960) Mar.

A study was made of the effect of 1 Mev electron irradiation on the mechanical properties of lithium fluoride

single crystals tested in compression. The yield point,  $\sigma$ , was shown to vary with the irradiation dose,  $\phi$ , according to the law  $\sigma = \sigma_u + A[1 - \exp(-B\phi)]^{1/2}$ , where  $\sigma_u$ , A and B are constants. This relationship was derived theoretically by considering the passage of dislocations through radiation induced obstacles dispersed in the slip plane, together with the capture of point defects by existing obstacles. The empirical relationship  $\sigma = \kappa\phi^{1/2}$ , previously used for radiation hardening in metals, is capable of representing only the medium dose results, but clearly does not fit at either low or high doses. A new mechanism of cracking in heavily irradiated lithium fluoride, similar to that proposed by Cottrell for alpha iron, was observed. With compression along a [001] axis, cracks are initiated at the intersections of orthogonal {100} type slip planes and extend on the {100} cleavage plane passing through the intersection and parallel to the compression axis. (auth)

**17058**

THE DAMAGE AND RECOVERY OF NEUTRON IRRADIATED TUNGSTEN. M. W. Thompson (Atomic Energy Research Establishment, Harwell, Berks, Eng.). *Phil. Mag.* (8) 5, 278-96 (1960) Mar.

Residual electrical resistivity was used as an index of the damage present in tungsten irradiated in a reactor at 4° and 77°K. A comparison was made between four different specimens prepared from cold-drawn wire respectively annealed before irradiation at 2000, 1500, 800°C, and not at all. A fifth specimen was prepared from wire in a different state of purity. Four stages of recovery were identified, the first occurring below -170°C, the second at -170° to 350°C with an activation energy of 0.25 to 1.7 ev, the third at 350° to 450°C with a single activation energy of 1.7 ev, and the fourth above 450°C. Second-stage recovery was enhanced by the presence of cold-work, affected by impurities; and in well-annealed samples after light irradiations it was suppressed. A comparison of recovery with that in other metals leads to the conclusion that vacancies in tungsten migrate at 400°C with an activation energy of 1.7 ev. The general suggestion is advanced that vacancy migration occurs in all metals at a temperature approximately 20% of the absolute melting point  $T_m$  K, with an activation energy roughly  $5 \times 10^{-4} T_m$  ev. Recovery in tungsten above -170°C is attributed to the release of interstitials from traps associated with impurity atoms and dislocation lines. The free interstitial is assumed to become mobile below -170°C. The resistance as a function of dose curve for cold-worked tungsten shows acceleration and this is considered as evidence for the action of spikes on the unstable arrays of vacancies produced by deformation. A quantitative theory of damage and recovery developed from the above model predicts the observed behavior of the five types of tungsten specimen. (auth)

**17059**

ELECTRICAL CONDUCTIVITY OF X-IRRADIATED KCl. R. W. Christy and E. Fukushima (Dartmouth Coll., Hanover, N. H.). *Phys. Rev.* 118, 1222-5 (1960) June 1.

The conductivity of Harshaw KCl crystals was measured isothermally as a function of time in the temperature range 150 to 200°C, after exposing the crystals at room temperature to x ray doses sufficient to produce about  $10^{16}$  F centers/cm<sup>3</sup>. Besides the F band, a V band at about 5.75 ev is produced. If the F band is eliminated by optical bleaching before the measurement but the V band remains, the conductivity increases monotonically to an asymptotic value, which is equal to the conductivity of the unirradiated crystal for virgin samples but is lower for samples which have been annealed in air at 260°C beforehand. If both the F band and the V band are present, the conductivity

increases more rapidly at first, and then decreases to an asymptotic value. The behavior is qualitatively similar to that previously observed in NaCl, though there are significant differences in the optical absorption spectrum and temperature dependence of the conductivity changes. (auth)

**PHYSICS****General and Miscellaneous****17060 AEDC-TR-59-20**

National Bureau of Standards, Washington, D. C. TABLES OF THERMODYNAMIC PROPERTIES OF AIR INCLUDING DISSOCIATION AND IONIZATION FROM 1,500°K TO 15,000°K. Joseph Hilsenrath, Max Klein, and Harold W. Woolley. Dec. 1959. 147p. (AD-229934).

Tables are presented, at close spacing in density ( $\Delta \log \rho / \rho_0 = 0.2$  from -7 to +2), of the thermodynamic properties of air from 1,500 to 15,000°K. The properties tabulated are: the number of moles,  $Z^* = PV/RT$ , the dimensionless functions for internal energy,  $E^*/RT$ , enthalpy,  $H^*/RT$ , entropy,  $S^*/R$ , and the pressure,  $P$ , in atmospheres. Here the asterisk indicates that the properties are for the equilibrium mixture treated as an ideal gas (without so-called van der Waals effects). The underlying equations for this work and the input data are discussed briefly. A comparison is made between the reported values and the work of Gilmore, of the Rand Corporation, and of Predvoditelev and associates, of the U.S.S.R. (auth)

**17061 AFCRC-TN-59-591**

New York Univ., New York. Inst. of Mathematical Sciences.

ON THE DETERMINATION OF THE FREE ELECTRON DISTRIBUTION OF AN IONIZED GAS. Irvin Kay. Sept. 1959. 35p. Contract AF19(604)-3495. (EM-141; AD-228142).

A standard simplified model for the problem of determining the free electron distribution in an ionized gas by radio sounding experiments is discussed, and a relation between the elements of the corresponding scattering matrix is derived. Under the conditions assumed, a closed form expression for the charge distribution in terms of a reflection coefficient, which is a rational function of frequency, is obtained. (auth)

**17062 AFOSR-TN-59-633**

Plasmadyne Corp., Santa Ana, Calif.

EQUILIBRIUM THERMODYNAMIC PROPERTIES OF HELIUM TO 60,000 K. Technical Note No. 4. Gordon L. Cann and Adriano C. Ducati. June 18, 1959. 88p. Project No. 37507. Contract AF49(638)-54. (P-4TN069-54; AD-228210).

Helium was considered for use as a propellant in a plasma propulsion system because of its low molecular weight. To obtain reasonable exhaust velocities (greater than 10,000 m/sec) it is necessary to heat the gas to temperatures at which an appreciable ionization occurs. In order to assess the potentially available exhaust velocities when ionization is present, it is necessary to have a Mollier chart to determine isentropic expansions. The thermodynamic properties of helium were computed over a temperature range of 6000 to 60,000°K and a pressure range of  $10^{-4}$  to  $10^{-2}$  atm. A Mollier chart was constructed from this data. (auth)

**17063 HW-38235**

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

RESONANCE CAPTURE OF NEUTRONS IN METAL AND OXIDE CYLINDERS. M. V. Davis. July 20, 1955. Decl. June 10, 1960. 9p. OTS.

Calculations were made of the resonance capture of neutrons in cylinders of U, UO<sub>2</sub>, Th, and ThO<sub>2</sub>. The measurements were made by comparing the effect of Cd covered slugs of various materials on Test Pile reactivity with the effect caused by a Cd covered void. The results, including resonance escape probability and effective resonance integral, are tabulated. (C.H.)

**17064 KAPL-M-D1G-TD-12**

Knolls Atomic Power Lab., Schenectady, N. Y.

A STABILITY ANALYSIS OF THE FINITE DIFFERENCE REPRESENTATION OF THE ENERGY EQUATION. D. C. Maxwell. May 3, 1960. 55p. Contract W-31-109-Eng-52. OTS.

Two explicit finite difference approximations were used to represent the energy equation in a water channel: the plenum node as used in ART and the pipe node as used in SPY. In addition to instability, the pipe node exhibited a characteristic known as "ringing" when the inlet water temperature to the node changed rapidly. An investigation of ringing and stability was made. Analytical methods were used to predict the critical value of the time interval  $\Delta t$ , and experimental verification on the IBM-704 was obtained. A finite difference approximation called a "stable pipe" node was defined. The one node analysis proved that the normal pipe node will exhibit ringing even if the calculating time interval,  $\Delta t$ , equals zero. If the upper limit on the stability criteria were used, a linear buildup of error is likely. For proper attenuation of the error a  $\Delta t$  equal to no more than one-half of the upper limit was recommended. (M.C.G.)

**17065 LA-2383**

Los Alamos Scientific Lab., N. Mex.

COLLISION INTEGRALS AND TRANSPORT PROPERTIES FOR GASES OBEYING AN EXPONENTIAL REPULSIVE POTENTIAL. APPLICATION TO HYDROGEN AND HELIUM. Joseph B. Mann. Nov. 1959. 58p. Contract W-7405-eng-36. OTS.

A set of reduced collision integrals,  $\Omega^{(1,s)*}$ , was calculated for gases obeying an exponential repulsive potential  $\phi = \epsilon e^{\alpha(1-r/2)}$ . The integrals are tabulated over a wide range of the reduced temperature,  $kT/\epsilon$ , for each of 8 values of the exponential parameter  $\alpha$ . Also tabulated are the auxiliary functions necessary for calculation of the third approximation to the coefficients of viscosity, thermal conductivity, and self-diffusion, and of the second approximation to the reduced thermal diffusion ratio. In addition, tabulations are made of three common combinations of the collision integrals, A\*, B\*, and C\*; the quantity  $\delta_f$ , employed in Hirschfelder's Eucken correction, is tabulated. The parameters  $\alpha$  and  $\epsilon$  are determined for helium using experimental data to 2000°K. The resulting potential curve,  $\phi \times 10^{12} = 0.0745 e^{8.5(1-r/2)}$  ergs, r in angstroms, is in good agreement with earlier determinations of the potential at both high and low energies of interaction. Literature values of viscosity (to 1100°K) are used to determine the parameters for hydrogen, which are then employed to predict the variation of thermal conductivity with temperature. (auth)

**17066 LA-2390**

Los Alamos Scientific Lab., N. Mex.

SPACE, ENERGY, AND TIME DISTRIBUTION OF NEUTRONS AT THE GROUND-AIR INTERFACE—CALCULATED BY MONTE CARLO CODE NHM. Wendell A. Biggers, Leon J. Brown, and Kenneth C. Kohn. Jan. 4, 1960. 177p. Contract W-7405-eng-36. OTS.

A calculation, named NHM for Neutron, Hydrodynamic, Monte Carlo code, was done on the IBM-704 with the following objectives, the results of which are included in this report: (1) to determine if such a method is sufficient, with present cross section knowledge, to give neutron fluxes and spectra from nuclear devices as a function of distance and time; (2) to ascertain the validity of assumptions of the location of the source of gamma rays from neutron capture in nitrogen; and (3) to record the number and energy of neutrons entering and leaving the ground as a function of distance and time. All of the above were calculated for the case of a 10 to 15 kt fission device detonated 300 feet above Nevada soil. The degree of agreement with experimental data is shown. (auth)

**17067 LA-2398**

Los Alamos Scientific Lab., N. Mex.

HEAT CAPACITY OF PLUTONIUM METAL BELOW 420°K. T. A. Sandenaw, C. E. Olsen, and R. B. Gibney. Feb. 1960. 26p. Contract W-7405-eng-36. OTS.

The heat capacity of plutonium as a function of temperature below 300°K is represented by curves and least-squared equations for specimens of different purities and isotopic contents. Values of the electronic contribution coefficient, the Debye characteristic temperature, and energy density of states are reported, together with entropy and enthalpy at 1.9 to 298°K, and at 420°K. A figure showing the heat capacity behavior at 355°K to 420°K is also given. Anomalies in the heat-capacity curves are discussed, evidence from other types of experiments is presented to confirm their existence and significance, and possible explanations for them are considered. (auth)

**17068 NP-8655**

Aktiebolaget Atomenergi, Stockholm and Sweden. Atom-komitee, Stockholm.

PROCEEDINGS OF THE MEETING ON THE USE OF SLOW NEUTRONS TO INVESTIGATE THE SOLID STATE, STOCKHOLM, OCTOBER 1957. Feb. 1958. 156p.

A meeting on the use of slow neutrons to investigate the solid state was held in Stockholm on October 3-4, 1957. The main objective was to illuminate the present state of research, both theoretical and experimental, in this relatively new field, where neutrons are proving to be a useful tool in obtaining data on the dynamics of crystals and magnetic systems. Separate abstracts were prepared for 10 of the 11 papers presented. (W.D.M.)

**17069 NP-8655(p.1-30)**

Atomic Energy of Canada Ltd., Chalk River, Ont.

CRYSTAL AND LIQUID DYNAMICS BY NEUTRON SPECTROMETRY. B. N. Brockhouse. p.1-30 of PROCEEDINGS OF THE MEETING ON THE USE OF SLOW NEUTRONS TO INVESTIGATE THE SOLID STATE, STOCKHOLM, OCTOBER 1957.

Work at Chalk River on neutron spectrometry is outlined, which deals with the neutron equivalent of the Raman effect. The wavelength or propagation vector of monoenergetic neutrons scattered in some particular direction by the specimen is measured. Scattering by single crystals and liquids is considered. (W.D.M.)

**17070 NP-8655(p.31-9)**

United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England.

A DAMPED-PHONON THEORY OF NEUTRON SCATTERING BY LIQUIDS. I. Butterworth and W. Marshall. p.31-9 of PROCEEDINGS OF THE MEETING ON THE USE OF SLOW NEUTRONS TO INVESTIGATE THE SOLID STATE, STOCKHOLM, OCTOBER 1957.

Measurements are reported on the inelastic scattering

of 14°K neutrons by liquid and solid lead. It is observed that scattering from the liquid is very similar to that from the solid. An attempt is made to explain neutron scattering from a liquid near its melting point by modifying the theory of scattering from a crystal. Damping of transverse and longitudinal phonons is considered. The validity of the modified theory is tested for the case of liquid lead. (W.D.M.)

**17071** NP-8655(p.40-57)

United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England.

COLD NEUTRON RESEARCH AT HARWELL. P. A. Egelstaff. p.40-57 of PROCEEDINGS OF THE MEETING ON THE USE OF SLOW NEUTRONS TO INVESTIGATE THE SOLID STATE, STOCKHOLM, OCTOBER 1957.

The development of a cold neutron source of high flux is discussed in some detail. Experiments carried out with the neutron source include neutron scattering on Be single crystals, cold-worked Cu, large crystals of silica, and lead single crystals. (W.D.M.)

**17072** NP-8655(p.58-69)

Oxford Univ. Clarendon Lab.

THE THEORY OF NEUTRON SCATTERING BY MAGNETIC SUBSTANCES. R. J. Elliott. p.58-69 of PROCEEDINGS OF THE MEETING ON THE USE OF SLOW NEUTRONS TO INVESTIGATE THE SOLID STATE, STOCKHOLM, OCTOBER 1957.

Neutrons are readily available with wavelengths in the range 1 to 10 Å, and from their elastic scattering the ordering of electronic magnetic moments may be determined. These neutrons have energies of order  $10^{-2}$  ev so that energy levels within this energy of the ground states may be studied by inelastic scattering. Since the ordering energies of many magnetic substances are in this region, the energy levels associated with ordering may also be studied. Some of the theoretical calculations of these quantities on various models are reviewed, and their relation to neutron diffraction studies of magnetic solids is discussed. (W.D.M.)

**17073** NP-8655(p.70-9)

France. Commissariat à l'Énergie Atomique. Centre d'Etudes Nucléaires, Saclay.

NEUTRON MAGNETIC SCATTERING IN THE PARAMAGNETIC REGION. P. G. de Gennes. p.70-9 of PROCEEDINGS OF THE MEETING ON THE USE OF SLOW NEUTRONS TO INVESTIGATE THE SOLID STATE, STOCKHOLM, OCTOBER 1957.

The correlation functions for different spins taken at different times were evaluated in the limit of high temperatures. The shape and half-width of the energy spectrum of the neutrons magnetically scattered by such a spin assembly were obtained. (W.D.M.)

**17074** NP-8655(p.80-97)

France. Commissariat à l'Énergie Atomique. Centre d'Etudes Nucléaires, Saclay.

THE SACLAY MECHANICAL SELECTOR AND ITS APPLICATION TO CRITICAL SCATTERING MEASUREMENTS IN IRON. B. Jacrot. p.80-97 of PROCEEDINGS OF THE MEETING ON THE USE OF SLOW NEUTRONS TO INVESTIGATE THE SOLID STATE, STOCKHOLM, OCTOBER 1957.

A mechanical monochromator was built with a resolution half-width of 0.2 Å and a variable wavelength. There are two rotors 1 meter in diameter with slits 1.5 cm wide and 5 cm long. The calculated stress for the rotor and some measurements on vibrations with the rotors running

are shown. A sample of iron was placed in the chopper beam, and the shape of the spectrum after scattering as a function of temperature was studied. (W.D.M.)

**17075** NP-8655(p.98-111)

Aktiebolaget Atomenergi, Stockholm.

INELASTIC SCATTERING OF COLD NEUTRONS FROM ALUMINUM. K. E. Larsson. p.98-111 of PROCEEDINGS OF THE MEETING ON THE USE OF SLOW NEUTRONS TO INVESTIGATE THE SOLID STATE, STOCKHOLM, OCTOBER 1957.

Experimental equipment including a Be filter, slow chopper, and a 100 channel time analyzer was constructed at the Swedish Reactor R-1 for a study of inelastic scattering of cold neutrons by solids. The setup was used for measurements on an aluminum crystal. Results for particular angular settings of the crystal are given. (W.D.M.)

**17076** NP-8655(p.112-14)

United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England.

POSSIBILITIES AND LIMITATIONS OF THE USE OF SWIFTLY-MOVING SPECIMENS IN NEUTRON DIFFRACTION. R. D. Lowde. p.112-14 of PROCEEDINGS OF THE MEETING ON THE USE OF SLOW NEUTRONS TO INVESTIGATE THE SOLID STATE, STOCKHOLM, OCTOBER 1957.

Some brief remarks are made about the diffraction phenomena which would be produced by an over-all translational motion of the scatterer as a whole. The problem of what happens when a crystalline scatterer is moved at a velocity comparable to that of the incident neutrons is considered. (W.D.M.)

**17077** NP-8655(p.121-42)

Joint Establishment for Nuclear Energy Research, Kjeller, Norway.

NEUTRON DIFFRACTION STUDIES OF MAGNETIC SOLIDS. T. Riste. p.121-42 of PROCEEDINGS OF THE MEETING ON THE USE OF SLOW NEUTRONS TO INVESTIGATE THE SOLID STATE, STOCKHOLM, OCTOBER 1957.

A selective review is presented of the work which has been carried out in the field of magnetic diffraction of neutrons. (W.D.M.)

**17078** NP-8655(p.143-53)

Uppsala Univ. Inst. of Theoretical Physics.

ON THE INFLUENCE OF THE HEAT MOTION OF THE ATOMS ON NEUTRON DIFFRACTION IN CRYSTALS. I. Waller. p.143-53 of PROCEEDINGS OF THE MEETING ON THE USE OF SLOW NEUTRONS TO INVESTIGATE THE SOLID STATE, STOCKHOLM, OCTOBER 1957.

The calculation of the differential cross section for the scattering of neutrons by crystals taking into account the heat motion of the crystal atoms is reviewed. Multiple scattering is neglected, and the discussion is limited to the Born approximation. Only the harmonic approximation to the motion of the crystal atoms is considered. (W.D.M.)

**17079** NP-8690

Carnegie Inst. of Tech., Pittsburgh.

ATOMIC LINE SHAPES FROM A PLASMA. Technical Report No. 3. Bernard Mozer. [1959?]. 209p. Contract Nonr-760(15).

Several line shapes emitted by atoms in a plasma were calculated. The free ions and electrons in the gas which are responsible for broadening and shifting the emitted radiation are considered to be classical particles. The simultaneous effect of these perturbers on the emitting

atom is treated by considering the ions in the static approximation and the electrons in the impact approximation. Strict regard is paid to the validity of these approximations. The line shapes are calculated by a method which assumes that the static ionic electric field splits the line into its Stark components. The impact electrons then broaden each component causing them to overlap. The resulting line shape is obtained by averaging the broadened, overlapping Stark components over all ionic fields multiplied by an appropriate distribution. A theory of impact-broadened overlapping lines developed by Baranger, and Kolb and Griem was used to calculate the effect of the electrons. New ionic field distributions which are important for hydrogen line shapes were calculated by a new method which included the correlations between the charged particles in the gas. A calculated Balmer  $\beta$  line shape was in close agreement with a recent precise measurement. The close agreement between these results emphasizes the importance of the electrons in directly broadening the Stark components and indirectly modifying the ionic field distribution. (auth)

**17080** NP-8706

Columbia Univ., New York. Columbia Radiation Lab. RESEARCH INVESTIGATION DIRECTED TOWARD EXTENDING THE USEFUL RANGE OF THE ELECTROMAGNETIC SPECTRUM. First Quarterly Progress Report [for] December 16, 1959 through March 15, 1960. P. Kusch. 42p. Contract DA-36-039 SC-78330. (CU-3-60-SC-78330-Phys.).

A Cherenkov radiation in the K-band range was observed in a system that has recently been under design and study. An experimental investigation of the parameters governing the generation of power was started. An M-band maser radiotelescope is in an advanced stage of design and construction and details of the system are described. The purpose of the radiotelescope is to obtain data from which it should be possible to determine the density of oxygen in the atmosphere as a function of height above the earth's surface. Progress in the design of a maser to operate at the frequency of the hyperfine structure line of atomic hydrogen is reported. Studies directed to the achievement of maser action at infra-red frequencies are continuing. Molecular spectroscopy by use of masers is discussed. Work on a variety of studies of atomic hyperfine structures by several techniques is reported. (See also NP-8072.) (auth)

**17081** NP-8769

Uppsala Univ. SOME ASPECTS ON THE RECENT DEVELOPMENT OF THE THEORY OF THE ELECTRONIC STRUCTURE OF ATOMS. Technical Note No. 27. Per-Olov Löwdin. June 1, 1959. 101p. Contract AF61(514)-1200.

Presented at the second Robert A. Welch Foundation Conference on Chemical Research, II. Atomic Structure, Houston, Texas, December 1-3, 1958.

A discussion of atomic structure theory confined essentially to many-electron atoms is presented. Angular properties are examined, and it is shown that atomic wave functions of pure angular momentum such as spin, orbital angular momentum, and total angular momentum can be constructed by means of the recently developed projection operator technique. Several modifications of an approach in which superposition of configurations is used are discussed in detail. The wave functions resulting from this approach look complicated but may often be simplified by going over to the basic set of spin orbitals which is characterized by having maximum occupation numbers. (J.R.D.)

**17082** NP-8770

Uppsala Univ.

ELECTRONIC CORRELATION ENERGY IN 3- AND 4-ELECTRON ATOMS. Technical Note No. 32. Jan Lindberg and Harrison Shull. Nov. 1, 1959. 28p. Contract AF61(514)-1200.

The electronic correlation energy in 3- and 4-electron atomic systems is compared to previously well established correlation energies in 2-electron atoms. It is shown that the distribution of correlation energy in the K shell of these atoms between radial and angular correlation parallels that of the 2-electron system very closely. It is found, however, that the correlation in the L shell of the Be ground state is almost purely angular correlation energy. There is negligible correlation energy associated with K-L interaction. Analysis of the Z dependence of the correlation energy of 4 electron atoms shows a term linear in Z. It is suggested that this term arises from degeneracies existing in the limit of infinite Z, and a tabulation of states expected to have this property is given. The analysis suggests a convenient scheme for constructing a semi-empirical method for estimating atomic energies rather accurately. It is pointed out that a similar analysis for molecules in terms of the internuclear parameters suggests there may be inherent difficulties in constructing such a scheme for the molecular case. (auth)

**17083** NYO-9033

Rochester, N. Y. Univ. Inst. of Optics.

A THEORETICAL AND EXPERIMENTAL STUDY OF OPTICAL FIBERS. Robert J. Potter. Apr. 1, 1960. 146p. Contracts AT(30-1)-875 and AF33(616)-6171. OTS.

A geometrical treatment was used to outline the theoretical properties of optical fibers which are imperfect as well as geometrically and optically perfect. Experiments were performed to measure some of the optical properties of individual fibers and fiber bundles. Equations which describe the total flux transmitted and the angular distribution of the emergent light from straight cylindrical fibers of circular cross section were derived and numerically evaluated. The effects of skew rays on these and other interesting geometrical properties were studied. Also some of the equations which describe the performance of conical and polygonal fibers were formulated. The effects of light scattering, variation in index of refraction, bending, and absorbing coatings on the performance of fibers were considered. Measurements of the attenuation and angular distribution of the emitted light from plastic scintillating fibers were made. Using the theoretical equations, it was deduced that these fibers are characterized by an internal reflectivity of  $0.993 \pm 0.002$  and an absorption coefficient of  $0.015 \pm 0.003 \text{ cm}^{-1}$ . Measurements of the total light transmitted by clad glass fibers indicate that these fibers are characterized by an internal reflectivity of  $0.9993 \pm 0.0002$  and an absorption coefficient of the order of  $10^{-4} \text{ cm}^{-1}$ . Further it was found that presently available fibers cause a decollimation of light which is essentially independent of the fiber dimensions and the angle of incidence. This effect is probably due to a combination of refractive index variation as well as scattering of light within the fibers. Some experimental data on glass fiber bundles are also included. (auth)

**17084** R59SD432

General Electric Co. Missile and Space Vehicle Dept., Philadelphia.

DESIGN CONSIDERATIONS OF A STEADY DC MAGNETOHYDRODYNAMIC ELECTRICAL POWER GENERATOR. George W. Sutton. Sept. 15, 1959. 50p. Contract AF04(647)-269. (AD-227885).

The design of Magnetohydrodynamic generator is considered, including the length, pressure, magnetic field strength, and losses. The geometry chosen is a straight channel of variable cross section. Only d-c power generation is considered utilizing temperatures which may be obtained from conventional thermal sources. (auth)

**17085** SCTM-171-55(51)

Sandia Corp., Albuquerque, N. Mex.

TURBULENCE DEGRADATION OF SHOCKS. C. C. Hudson, Aug. 9, 1955. 10p. OTS.

An experiment is described in which shock is allowed to pass through a set of grids to measure the transmitted shock. The transmitted shock, as measured by an interferometer, has a strength of about  $\frac{1}{6}$  that of the incident for three grids. (auth)

**17086** SCTM-207-54(54)

Sandia Corp., Albuquerque, N. Mex.

SOLUTION OF THE INTEGRAL EQUATION WHICH DETERMINES RADAR-CROSS-SECTION FOR A SCATTERING GROUND. R. A. Hessemeyer, Jr. and C. S. Williams, Jr. Sept. 15, 1954. 12p. OTS.

In the analysis of pulse returns from a scattering ground, it is necessary to determine one of the functions of the integrand of the convolution integral (where the other function of the integrand as well as the integral itself are known) in order to find the radar-cross-section of the terrain as a function of angle from the vertical. Several ways of doing this are discussed and a computer is proposed which will rapidly solve for the desired function. (auth)

**17087** TID-5725

Massachusetts Inst. of Tech., Cambridge. Lab. for Nuclear Science.

FINAL REPORT OF RESEARCHES UNDER CONTRACT N5ori-07806 AND Nonr-1841(16). [Summary of Work Sponsored by ONR and AEC for Period: April 1, 1946 to May 15, 1958]. May 15, 1958. 106p. OTS.

A summary of work in basic nuclear physics accomplished from April 1, 1946, to May 15, 1958, is presented. The summary includes: a description of research carried on under several separate programs; a summary of major problems studied; and lists of unpublished technical reports and a bibliography of publications in various fields of research. (W.L.H.)

**17088** TID-5932

Carnegie Inst. of Tech., Pittsburgh.

F-CENTER GROWTH IN KCl. Phillip Vickers Mitchell. Jan. 1960. 103p. Contract AT(30-1)-1828. OTS.

Measurements were made at room temperature of the growth of the F-band in KCl crystals during 140 kvp x irradiation. The growth is examined as a function of intensity of irradiation, plastic deformation, and heat treatment. The observations indicate that the early rapid growth of coloration is due to vacancies initially in the lattice and that the later slow growth is due to the generation of new vacancies at dislocations. Heat treatment increases the saturation level of the early stage and deformation reduces the rate of growth in the later stage. The shape of the growth curve is derived and is found to fit the data. (auth)

**17089** AEC-tr-4096

GRAPHIC ELECTRON STUDY OF THE STRUCTURE OF THE MOLECULES OF GASEOUS HALIDES OF THE ALKALI METALS. P. A. Akishin and N. G. Rambidi. Translated by A. L. Monks (Oak Ridge National Lab.) from *Vestnik Moskov. Univ., Ser. Mat., Mekhan., Astron., Fiz. i Khim.*, No. 6, 223-30(1958). 17p. (Includes original, 8p.). JCL or LC.

The divergence in previously published electronographic and radiospectroscopic data on the interatomic distances of Li, Na, K, Rb, and Cs halides was investigated. Attempts were made to find the geometric configuration of the dimer molecules of the alkali element halides. (C.J.G.)

**17090** JPRIS-2627

SYMPOSIUM ON THE "ELECTRON THEORY OF SOLIDS." Translation of excerpts from *Wu Li Hsüeh Pao* 14, No. 3, (1958). 41p. OTS.

Excerpts from papers on recent advances in energy band theory, theories of electronic transition in crystals, the theory of collective vibration of electrons, theory of quantization, superconductivity, and properties of metals in magnetic fields are discussed. (J.R.D.)

**17091** NP-tr-437

COLUMN IONIZATION IN GASES AT ELEVATED PRESSURES. G. Jaffé. Translated by R. C. Murray (U.K.A.E.A. Atomic Energy Research Establishment) from *Physik. Z.* 30, 849-56(1929). 17p. JCL.

Data are reported for use in determining the saturation curves of potential and current flow in alpha-ionized gases. Measurements were made on air, O<sub>2</sub>, and CO<sub>2</sub> at 1, 2, 4, and 6 atm and on H<sub>2</sub> at 2, 4, 6, and 8 atm. The measurements on air, O<sub>2</sub>, and CO<sub>2</sub> were made at 750 to 4,500 mm Hg and electrode separation of 2 to 10 mm and on H<sub>2</sub> at 1,520 to 5,940 mm Hg and electrode separation of 5 to 20 mm. The problem of the pressure dependence of the recombination coefficient is discussed. (C.J.G.)

**17092**

A NEW MEASURING SYSTEM FOR QUANTUM EFFICIENCY MEASUREMENTS OF LUMINESCENT SUBSTANCES. G. T. Bauer (Industrial Research Inst. for Telecommunication Technique, Budapest). *Acta Phys. Acad. Sci. Hung.* 11, 225-34(1960). (In English)

An integrating measuring heat is described for the relatively simple and quick measurement of the quantum efficiency of luminescent substances. The quantum efficiencies of some crystal phosphors were determined by comparing them to materials of known quantum efficiencies. (auth)

**17093**

SPECTROSCOPIC TEMPERATURE MEASUREMENTS IN A SHOCK TUBE USING CN AS A THERMOMETRIC MOLECULE. W. H. Parkinson and R. W. Nicholls (Univ. of Western Ontario, London). *Can. J. Phys.* 38, 715-19(1960) June.

Rotational intensity measurements on the CN spectrum, excited through shock excitation of a powdered mixture of NH<sub>4</sub>Cl, KNO<sub>3</sub>, and C by helium-driven shock waves in argon were used to infer "rotational temperatures" of the gas between 6350 and 8750°K. The measured values agree well with gas kinetic temperatures inferred from simple gas dynamic theory and shock-wave velocity measurements. (auth)

**17094**

RESISTIVITY OF SOME METAL SYSTEMS OF RARE EARTHS-HYDROGEN. Joseph N. Daou. *Compt. rend.* 250, 3165-7(1960) May 9. (In French)

The electrical resistivity of the Pr-H system was studied on metallic foils obtained by cold rolling. The thermal variations of the electrical resistivity of the metal found by other investigators were confirmed, and no anomaly of structure was found in the interval from 25 to 500°C. The curve representing the variations of R/R<sub>0</sub>, where R<sub>0</sub> is the resistance of the metal at 500°C, is given as a function of the degree of hydrogenation. In the interval Pr to PrH<sub>2</sub>,

the curve consists of two segments joined at a point near  $\text{PrH}$ . The transition between the two regions is quite sharp. (J.S.R.)

17095

SOME EFFECTS OBSERVED IN STUDYING THE LUMINESCENCE OF ELECTRETS FROM  $\text{ZnS}$ . V. M. Fridkin (Inst. of Crystallography, Academy of Sciences, USSR). *Doklady Akad. Nauk S.S.R.* 131, 290-2(1960) Mar. 11. (In Russian)

The electret state in electroluminescent zinc sulfide induced stronger fluorescence. An intense luminescence is achieved by electret heating which is damped with depolarization. The described effects are the result of strong internal fields in  $\text{ZnS}$ . (R.V.J.)

17096

DIRECTIVES FOR PLANNING THE DIMENSIONS OF GAMMA IRRADIATORS. Ferenc Baintner and László Tihanyi. *Energia es Atomtech.* 13, 79-82(1960) Jan.-Feb. (In Hungarian)

The geometry of irradiation and methods for eliminating the penumbra in therapeutic radiology are discussed. Practical examples are given in computations of desired dimensions for the shield, port, and port diaphragm of a 400-c radiocobalt applicator. (JPRS.)

17097

POSITIVE COLUMN FORMATION IN ION SOURCES EMPLOYING SURFACE IONIZATION. P. L. Auer and H. Hurwitz, Jr. (General Electric Co., Schenectady, N. Y.). *J. Appl. Phys.* 31, 1007-9(1960) June.

In order to gain some insight in the problem of space charge neutralization of ion beams, use is made of a previous calculation to discuss the unidimensional flow of positive ions in a tube where both ions and electrons issue from an emitter surface but only ion current is collected by means of an accelerating electrode. The resulting ion flow can be neutralized to varying degrees by the electrons present. It was found that in the absence of collisional interactions the potential distribution in the tube may closely resemble the electrode sheath and positive column structure familiar to glow discharges. This is the situation to be expected whenever the ion current has values far in excess of that predicted from a zero degree of neutralization space charge limited theory. (auth)

17098

RANGE OF RADIATION INDUCED PRIMARY KNOCK-ONS IN THE HARD CORE APPROXIMATION. D. K. Holmes and G. Leibfried (Oak Ridge National Lab., Tenn.). *J. Appl. Phys.* 31, 1046-56(1960) June.

The slowing down of a primary displaced atom of high energy in a solid is investigated in detail. Physically interesting quantities, such as the total distance travelled and the vector distance to the end of the path, are discussed in terms of certain averages for hard core potentials with general dependence of the core radius on energy. These averages are explicitly calculated for a screened Coulomb potential for the purpose of comparison with experimental ranges observed in different metals. Theoretical values for the range can be derived. Comparison with the experimental data gives a value for the screening radius of the interaction potential which is about twice the value originally suggested by N. Bohr. (auth)

17099

ON THE THEORY OF THE CLOSE-SPACED IMPREGNATED CATHODE THERMIONIC CONVERTER. E. S. Rittner (Philips Labs., Irvington-on-Hudson, N. Y.). *J. Appl. Phys.* 31, 1065-71(1960) June.

The tables associated with the exact Langmuir space charge theory were represented to a maximum relative error of 0.01% by approximation formulas which are suitable for use with digital computers. Application of the exact theory to a thermionic converter comprising two close-spaced planar impregnated cathodes has permitted a critical evaluation of the approximate space charge theory of Nottingham. The influence of the electrode separation, the emitter and collector work functions and of the emitter temperature was investigated. Spectral emittance measurements on a cathode surface at two wavelength resulted in a more firmly based estimate of the radiation heat transfer between two impregnated cathodes and of the maximum efficiency of an ideal design. (auth)

17100

COMMENTS ON "DETERMINATION OF ATOMIC SCATTERING FACTORS." D. R. Chipman and Arthur Paskin (Materials Research Lab., Watertown, Mass.). *J. Appl. Phys.* 31, 1130-31(1960) June.

Comments are given concerning Roof's x-ray measurements of the atomic scattering factor of Al as obtained from absolute measurements on powders. It is believed that the wrong equation was used for relating powder intensities to the scattering factors, and incorrect values were used for some parameters. The corrected equation is given, and the form factors are renormalized so that they are equal at a given Bragg peak; thus indicating that all the data are in agreement. (B.O.G.)

17101

REPLY TO COMMENTS ON "DETERMINATION OF ATOMIC SCATTERING FACTORS." R. B. Roof, Jr. (Los Alamos Scientific Lab., N. Mex.). *J. Appl. Phys.* 31, 1131(1960) June.

Upon re-examination of the problem, it was concluded that Chipman and Paskin were correct in using the theoretical density rather than the experimental density in their calculation of the linear absorption coefficient of the sample. Review of further criticisms of the techniques leads to the conclusion that a calibration procedure must be employed in order to lead to an absolute determination of an atomic scattering factor. These calibration procedures are outlined. It is felt that this procedure is valid, since its use on data from samples other than Al yields scattering curves which, when compared with theoretical curves, result in correct signs for the real and imaginary parts of the anomalous dispersion corrections. (B.O.G.)

17102

USE OF  $\text{SF}_6$  FOR CALIBRATION OF THE ELECTRON ENERGY SCALE. G. J. Schulz (Westinghouse Research Labs., Pittsburgh). *J. Appl. Phys.* 31, 1134(1960) June.

It is pointed out that the energy scale obtained by the retarding potential difference method may, under certain conditions, be erroneous. The potential along the path of the electron beam in the collision chamber is considered. From this consideration it was concluded that there is agreement between the energy scale established by retarding the electron beam in front of the collision chamber, so that both calibration by  $\text{SF}_6$  and electron retarding yields the proper zero energy scale. (B.O.G.)

17103

PROCEEDINGS OF THE FIFTH SYMPOSIUM ON MAGNETISM AND MAGNETIC MATERIALS, NOVEMBER 16-19, 1959, DETROIT, MICHIGAN. *J. Appl. Phys.* 31, Suppl. to No. 5 (1960) May. 426p.

The subjects covered by the conference are: magnetism, general and theory; garnets; permanent magnets; spin

waves and magnetostatic modes; computers and switching; anisotropy; techniques and devices; resonance; soft magnetic materials; ferrites and oxides; magnetic films; metals and alloys; magnetic salts; magnetic compounds and neutron diffraction; ferrimagnetic resonance effects; and miscellaneous. Separate abstracts have been prepared for some of the papers. (W.L.H.)

## 17104

MICROWAVE RESONANCE IN RARE EARTH IRON GARNETS. C. Kittel (Univ. of California, Berkeley). J. Appl. Phys. 31, Suppl. to No. 5, 11S-13S(1960) May.

An elementary discussion is given of the theory of g values and line widths in ferromagnetic resonances in certain rare earth garnets. The experimental facts are reviewed briefly. (auth)

## 17105

MAGNETIC INTERACTIONS AND DISTRIBUTION OF IONS IN THE GARNETS. S. Geller (Bell Telephone Labs., Inc., Murray Hill, N. J.). J. Appl. Phys. 31, Suppl. to No. 5, 30S-3S(1960) May.

Since the discovery of the magnetic yttrium and rare earth iron garnets, a systematic investigation was made of interactions of magnetic ions and the distribution of both magnetic and nonmagnetic ions in the garnets. The results of substitution of the tetravalent tin for  $Fe^{3+}$  ion in yttrium-iron garnet (balanced by substitution of  $Ca^{2+}$  for  $Y^{3+}$  ions) have led to the development by Gilleo of a statistical interaction theory which accounts well for the spontaneous magnetizations and Curie temperatures of the system. This theory was further strengthened by results from zirconium substituted yttrium-iron garnets and by its successful extension to substituted rare earth iron garnets. In the course of our investigations, many new garnets were discovered. Several of these have enabled us to observe directly interactions between magnetic ions in dodecahedral and octahedral sites, dodecahedral and tetrahedral sites, octahedral sites only and tetrahedral sites only. The work on the garnets was also adequately extensive to lead to the establishment of some rather simple rules pertaining to site preference of ions entering the garnets. (auth)

## 17106

RESONANCE EXPERIMENTS WITH SINGLE CRYSTAL YTTRIUM IRON GARNETS IN PULSED MAGNETIC FIELDS. Martin R. Stiglitz and Frederic R. Morgenthaler (Air Force Cambridge Research Center, Mass.). J. Appl. Phys. 31, Suppl. to No. 5, 37S-8S(1960) May.

A crystal sphere of YIG was placed in either a doubly resonant transmission type coaxial cavity or into a non-resonant transmission line device and biased with a dc magnetic field. A low power microwave signal in the S band frequency range (cw or pulsed) was used to excite resonance. Current pulses of approximately 1  $\mu$ sec duration and low duty cycle were sent through a low impedance coil that was wound around the cavity or transmission line, respectively. These pulses induced pulsed magnetic fields of the order of 1000 gauss, which (vectorially) added to the existing dc field. A microwave receiver, attached to the cavity output, detected weak oscillations at higher or lower frequencies. Shifts of 280 Mc were obtained with the cavity, and shifts of 1280 Mc above and 530 Mc below the driving frequency were obtained with the transmission type device. The detected signal is associated with either the rise of the current pulse, or the decay, or two signals may appear simultaneously corresponding, respectively, to the rise and decay. This depends upon the angular relation of the dc field with respect to the cavity or transmission line. (auth)

## 17107

ABSORPTION AND REFLECTIVITY MEASUREMENTS ON SOME RARE EARTH IRON GARNETS AND  $\alpha$ - $Fe_2O_3$ . P. C. Bailey (Westinghouse Electric Corp., East Pittsburgh, Penna.). J. Appl. Phys. 31, Suppl. to No. 5, 39S-40S(1960) May.

Measurements of the absorption coefficient of (111) crystal sections of  $\alpha$ - $Fe_2O_3$  were made in the visible and near infrared. Absorption peaks were observed centered at energies of about 12,000  $cm^{-1}$  and 16,000  $cm^{-1}$ . Reflectivity measurements on the  $\alpha$ - $Fe_2O_3$  crystals were carried out in the 30,000  $cm^{-1}$  to 400  $cm^{-1}$  range. Broad reflectivity peaks are found in the near ultraviolet at 24,500  $cm^{-1}$  and 26,000  $cm^{-1}$ , respectively. Very strong reflection peaks resulting from the lattice vibrations are present at energies smaller than 700  $cm^{-1}$ . Several quite sharp peaks are found in the absorption spectra of the rare-earth iron garnets of Dy, Ho, Er, and Yb in the 10,000 to 13,000  $cm^{-1}$  energy range. The circular dichroism of ytterbium iron garnet is displayed by means of absorption curves for the two senses of circularly polarized light. (auth)

## 17108

INSTABILITY OF MAGNETIC RESONANCE IN SINGLE CRYSTAL SPHERES OF YTTRIUM IRON GARNET.

Joseph I. Masters (Air Force Cambridge Research Center, Bedford, Mass.). J. Appl. Phys. 31, Suppl. to No. 5, 41S-2S(1960) May.

Instabilities in YIG spheres that exist above certain threshold power values of cw microwave field are studied using samples of about  $\frac{1}{4}$  to  $\frac{1}{2}$  mm diam, that have low power line widths of 1 oe or less. Whereas the characteristic behavior such as asymmetrical line shape, "jump" effect etc., is somewhat similar to that reported for disks, the phenomenon is generally different. It has been determined that this instability, which can occur at cw power levels below the threshold for significant spin wave growth, is due entirely to the heating effect of resonance absorption upon the anisotropy energy of the crystal lattice. As a result, the instability is characterized by a threshold curve that follows both the extrema and symmetry of the anisotropy curve for a given orientation. A straightforward theoretical explanation based on familiar relationships is outlined which fits the instability threshold vs. orientation curve. The temperature instability provides a technique for measuring the g factor that is believed to be more direct than previous methods. (auth)

## 17109

FERRIMAGNETIC RESONANCE IN IMPURITY DOPED YTTRIUM IRON GARNET (YIG). J. F. Dillon, Jr. and J. W. Nielsen (Bell Telephone Labs., Inc., Murray Hill, N. J.). J. Appl. Phys. 31, Suppl. to No. 5, 43S-4S(1960) May.

A research program aimed at understanding our earlier line width and anisotropy measurements on YIG has led to a study of ferrimagnetic resonance in doped crystals. YIG crystals were grown containing appropriate concentrations ( $\sim 0.01$  to  $5.0$  at.%) of various impurities, including the 4f rare earth elements, members of the iron transition group, and several non-magnetic elements. This paper gives new results for the variation of the field for resonance with crystal direction at several temperatures in the liquid hydrogen and liquid helium range. In the case of holmium, sharp peaks in the  $H_{res}$  vs. angle curve are seen which vary rapidly with temperature. The corresponding curves for the dysprosium containing sample do not show such sharp variations in (110), and at least in part do not vary with temperature below about 4K. Though Kittel's recent

theoretical results should apparently apply to the peaks in the holmium case, his results for the temperature dependence of the anomaly height and width do not correspond with the present data. (auth)

## 17110

SAMARIUM SUBSTITUTIONS IN YTTRIUM IRON GARNET. J. Richard Cunningham, Jr. and Elmer E. Anderson (U. S. Naval Ordnance Lab., White Oak, Md.). J. Appl. Phys. **31**, Suppl. to No. 5, 46S-6S(1960) May.

Polycrystalline garnets of the form  $(3-x)Y_2O_3 \cdot xSm_2O_3 \cdot 5Fe_2O_3$  were prepared where  $x$  was varied from 0 to 3 in six steps. Lattice constants were found to vary linearly from  $12.374 \pm 0.005$  Å for yttrium iron garnet ( $x = 0$ ) to  $12.533 \pm 0.005$  Å for samarium iron garnet ( $x = 3$ ). The theoretical x-ray densities were calculated and vary from 5.17 gms/cc for  $x = 0$  to 6.22 gms/cc for  $x = 3$ . Magnetic moments were measured from 77 to 600°K. No magnetic compensation points were observed. The Curie temperature for these garnets is  $570 \pm 10$ °K. Thermal magnetization curves for this series indicate that samarium substitution for yttrium produces very little change in the magnetization. The relative complex initial permeability was measured from dc to 2 kMc for several temperatures. The results of these measurements are discussed briefly. (auth)

## 17111

INITIAL PERMEABILITY CHARACTERISTICS OF MIXED YTTRIUM-GADOLINIUM IRON GARNETS. G. E.

McDuffie, Jr., J. R. Cunningham, Jr., and E. E. Anderson (U. S. Naval Ordnance Lab., White Oak, Md.). J. Appl. Phys. **31**, Suppl. to No. 5, 47S-8S(1960) May.

Complex initial permeability measurements were made on polycrystalline garnet toroids of the form  $(3-x)Y_2O_3 \cdot xGd_2O_3 \cdot 5Fe_2O_3$  where  $x$  ranged from zero (yttrium iron garnet) to three (gadolinium iron garnet). Both the real initial permeability  $\mu'$  and the imaginary initial permeability  $\mu''$  were measured at 23, -78, and -196°K over a frequency range of 1 kc to 2000 Mc. At room temperature, the low frequency value of  $\mu'$  was found to decrease with increasing gadolinium content. At lower temperatures the low frequency value of  $\mu'$  exhibits a minimum in  $x$  caused by the temperature dependent behavior of the two different magnetic sublattices. The frequency at which the maximum value of  $\mu''$  occurs was found to increase with the addition of gadolinium. No thermal relaxation was observed in these garnets, but rather the peaks in the curves shifted to slightly higher frequencies with decreasing temperature. (auth)

## 17112

SPECIFIC HEAT OF SOME RARE EARTH IRON GARNETS AND YIG AT LOW TEMPERATURES. Horst Meyer and A. B. Harris (Harvard Univ., Cambridge, Mass.). J. Appl. Phys. **31**, Suppl. to No. 5, 49S-50S(1960) May.

Heat capacity measurements of the iron garnets of Y, Gd, Er, Ho, and Yb between 1.4° and 20°K are presented. Below 5°K, the specific heat of YIG can be represented by the sum of a lattice term proportional to  $T^3$  and the spin-wave contribution  $2.15 \times 10^{-3} T^{5/2}$  joules/mole-deg. This last term agrees satisfactorily with that calculated from a spin-wave analysis, in which the exchange interaction coefficients were those derived from Pauthenet's magnetization data. The results of the magnetic specific heat of the rare earth ions could be interpreted in terms of a Weiss molecular field acting on these ions. For  $Gd^{3+}$  and  $Yb^{3+}$ , this field was found to be, respectively, about  $3.0 \times 10^6$  and  $1.5 \times 10^5$  oe below 20°K, in satisfactory agreement with that derived from Pauthenet's data. (auth)

## 17113

ON MAGNETOSTRICTION OF GADOLINIUM IRON GARNETS. K. P. Belov and A. V. Pedko (Moscow State Univ.). J. Appl. Phys. **31**, Suppl. to No. 5, 55S-7S(1960) May.

The temperature dependence of magnetostriction in the gadolinium ferrite having structure of a garnet was measured within the temperature range from liquid nitrogen up to the Curie point. At temperatures above the compensation point of sublattices,  $\theta_k$ , the magnetostriction isotherms are of the same kind as for ferromagnetics ( $\lambda_{II}$  and  $\lambda_{\perp}$  have opposite signs and the  $\lambda$  vs. H curves exhibit saturation). In cooling below  $\theta_k$  there is an effect of superposition of large volume magnetostriction of paraprocess on the "ordinary" magnetostriction, which results in the distortion of the magnetostriction isotherms ( $\lambda_{II}$  and  $\lambda_{\perp}$  are of the same sign and without saturation). It is shown that the "ordinary" magnetostriction is caused by the interaction of  $Fe^{3+}$  ions in sublattices a and d, while the volume magnetostriction of the paraprocess is caused by the interaction of  $Gd^{3+}$  and  $Fe^{3+}$  ions. (auth)

## 17114

STRONG FIELD MAGNETIZATION AT LOW TEMPERATURES AND APPROACH TO ABSOLUTE SATURATION OF THULIUM METAL. Warren E. Henry (U. S. Naval Research Lab., Washington, D. C.). J. Appl. Phys. **31**, 323S-4S(1960) May.

Magnetization studies of metallic thulium were carried out at low temperatures and in magnetic fields up to 70,000 gauss. Near 100°K, the magnetization (M) is linear in field and reaches 0.8 Bohr magnetons per atom of thulium at 70,000 gauss. At 4.2°K, a magnetization curve is traced in which the direction of concavity changes twice. In the high field range,  $(\partial M / \partial H)$  is decreasing and between 60,000 and 70,000 gauss, it is very small. At 70,000 gauss, the magnetization reaches 3.4 Bohr magnetons per atom of thulium, suggesting the validity of the  $^2F_{5/2}$  ground state assignment for metallic thulium. At 1.3°K, the magnetization is slightly lower at equivalent fields, but approaches the same 70,000 gauss value as at 4.2°K. The remanence is 0.3 Bohr magneton per atom at 4.2°K and 0.4 Bohr magneton per atom at 1.3°K. A pronounced hysteresis is observed in the liquid helium range. A sample motion technique is used in the measurements and the calibration carried out with pure nickel. (auth)

## 17115

MAGNETIC BEHAVIOR OF POLYCRYSTALLINE NEODYMIUM, HOLMIUM, AND ERBIUM FROM 300 TO 1500°K. Sigurds Arajs and D. S. Miller (U. S. Steel Corp., Monroeville, Penna.). J. Appl. Phys. **31**, Suppl. to No. 5, 325S-6S(1960) May.

The paramagnetic susceptibilities of polycrystalline Nd, Ho, and Er were determined from about 300 to 1500°K by the Faraday method. The inverse paramagnetic susceptibility vs. temperature ( $1/\chi$  vs. T) curve for Nd at high temperatures show two slight anomalies associated with a solid state phase transformation and the melting point, respectively. The paramagnetic susceptibility of hcp Nd does not satisfy the Weiss-Curie law due to the partial population of the energy levels above the ground state  $^4I_{15/2}$ . The paramagnetic susceptibility of Ho and Er is representable by the Weiss-Curie law. The experimental Bohr magneton numbers are in satisfactory agreement with those predicted by the Van Vleck theory. (auth)

## 17116

NEUTRON DIFFRACTION INVESTIGATIONS OF THE MAGNETIC ORDERING IN RARE EARTH NITRIDES.

M. K. Wilkinson, H. R. Child, J. W. Cable, E. O. Wollan, and W. C. Koehler (Oak Ridge National Lab., Tenn.). *J. Appl. Phys.* 31, Suppl. to No. 5, 358S-9S(1960) May.

Neutron-diffraction investigations on HoN and TbN at low temperatures show that both compounds become ferromagnetic with Curie temperatures of about 18 and 43°K, respectively. Although the paramagnetic scattering is consistent with moment values calculated for the free trivalent rare earth ions, the observed ferromagnetic moments are lower than the calculated values and indicate the effect of crystalline field interactions. Diffraction patterns from both compounds at 1.3°K show considerable ferromagnetic short-range-order scattering with characteristics which are different from those associated with critical magnetic scattering. (auth)

17117

THEORY OF THE LOW LYING STATES OF SOME RARE EARTH COMPOUNDS. G. T. Trammell (Oak Ridge National Lab., Tenn.). *J. Appl. Phys.* 31, Suppl. to No. 5, 362S-3S(1960) May.

The electrostatic crystalline torques acting on the magnetic ions in the rare earth nitrides are likely larger than those due to exchange. Some of the consequences of this are discussed. (auth)

17118

CALCULATION OF THE COUPLING TERMS NEGLECTED IN PERFORMING THE BORN-OPPENHEIMER SEPARATION FOR THE HYDROGEN MOLECULE ION. Donald W. Jepsen and Joseph O. Hirschfelder (Univ. of Wisconsin, Madison). *J. Chem. Phys.* 32, 1323-35(1960) May.

A method is given for calculating the coupling between the nuclear and electronic motion in the hydrogen molecule ion using the exact wave functions. Calculations are carried out for the transition  $1s\sigma-2s\sigma$  and compared with values obtained from simple approximate methods. Estimates are made of the cross sections for excitation and capture into the  $2s$  state during a proton-hydrogen atom collision, using approximate  $H_2^+$  wave functions to describe the state during collision. Finally, it is shown that a Born-Oppenheimer separation carried out in relative coordinates should be slightly more accurate than the usual treatment using fixed space coordinates. Two different types of relative coordinates suggest themselves for use at different ranges of internuclear separation. (auth)

17119

EFFECT OF PRESSURE ON THE SPECTRA OF COLOR CENTERS. R. A. Eppler and H. G. Drickamer (Univ. of Illinois, Urbana). *J. Chem. Phys.* 32, 1418-22(1960) May.

The effect of pressure on the spectra of certain color centers produced in the alkali halides by  $\gamma$  irradiation was measured to pressures as high as 166,000 atm. For the F center a shift to higher energies with increasing pressure is observed. The slope of the shift versus density is at least twice the value that would be predicted from Ivey's relation at low pressure, and decreases with increasing pressure. This indicates that the compressibility in the neighborhood of the F center is greater than in the bulk crystal, particularly at low pressure. For the M center in LiCl a shift to higher energy with increasing pressure is observed, about one-fifth as great as the shift observed for the F center. (auth)

17120

EMISSION OF ACTIVATED CADMIUM SELENIDE PHOSPHORS. M. Avinor and G. Meijer (N. V. Philips' Gloeilampenfabrieken, Eindhoven, Netherlands). *J. Chem. Phys.* 32, 1456-8(1960) May.

The emission bands of cadmium selenide activated by silver, copper, and gold, and coactivated by trivalent metals, were found at 0.92, 1.20, and 1.45  $\mu$ , respectively, at the temperature of liquid nitrogen. The silver band is completely quenched at room temperature. A near edge emission of CdSe was found at 0.72  $\mu$ . (auth)

17121

SPUTTERING OF SILVER BY LIGHT IONS WITH ENERGIES FROM 2 TO 12 KEV. Finn Grønlund and Walter J. Moore (Indiana Univ., Bloomington). *J. Chem. Phys.* 32, 1540-5(1960) May.

Electromagnetically analyzed ionic beams from a radio-frequency source were used to study the sputtering yield S (atoms per ion) for light ions normally incident on silver targets at energies from 2 to 12 kev. The yields displayed broad maxima with energy in the range studied. At 5 kev the following values of S were found:  $H^+$ , 0.035;  $D^+$ , 0.090;  $H_2^+$ , 0.077;  $D_2^+$ , 0.21;  $H_3^+$ , 0.11;  $D_3^+$ , 0.33;  $He^+$ , 0.48;  $N^+$ , 4.0;  $O^+$ , 4.4;  $Ne^+$ , 5.5. The angular distribution of sputtered silver followed a cosine dependence about the normal to the target surface even when the beam hit the target at oblique incidence. (auth)

17122

LUMINESCENCE SPECTRUM OF  $PmCl_3$ . John G. Conway and John B. Gruber (Univ. of California, Berkeley). *J. Chem. Phys.* 32, 1586-7(1960) May.

The luminescence of  $PmCl_3$  was studied with two 1-g  $LaCl_3$  crystals containing 2 and 20 mg of  $PmCl_3$ . These crystals were found to be self-luminescent from  $Pm^{147}$  decay, to blacken when cooled to room temperature, and to fluoresce. The fluorescence is intensified by ultraviolet light at 8300 Å in the 2% crystal and at all lines in the 0.2% crystal. The luminescence lines for Pm are grouped at 4610, 4980, 5410, 5900, 6600, 7420, and 8300 Å. (D.L.C.)

17123

GROWTH OF LARGE METAL SINGLE CRYSTALS FOR NEUTRON DIFFRACTION. A. Modrzejewski, B. Buras, and R. Czarnecki (Polish Academy of Sciences, Warsaw). *Kerntechnik* 2, 153-7(1960) May. (In German)

Large single crystals of Al, Cu, Pb, and Zn intended for neutron-diffraction studies, were grown by the slow cooling of the melt. They were tested and oriented with x radiation, mechanically cut, and finally etched. The planes of the single crystals were 40 to 50 mm high and 120 to 150 mm long with a mosaic distribution of 1 to 20 minutes of arc. (tr-auth)

17124

THE EFFECT OF STRONG ELECTRIC AND MAGNETIC FIELDS ON THE DEPOLARIZATION RATIOS OF GASES. A. L. Andrews and A. D. Buckingham (Oxford Univ.). *Mol. Phys.* 3, 183-9(1960) Mar.

The influence of a strong electric field F on the polarization of light scattered elastically by small gaseous molecules is investigated. Two effects are found: (i) The field distorts the molecules, thereby changing their polarizabilities. If they are isotropically polarizable when  $F = 0$ , and capable of scattering only polarized light from a parallel beam, this distortion may lead to depolarization. For inert gas atoms, this depolarization is proportional to  $F^4$ , and normally very small, but for tetrahedral molecules it is proportional to  $\beta^2 F^2$ , where  $\beta$  is the first hyperpolarizability of the molecule. (ii) F tends to orientate anisotropic molecules, thereby affecting the polarization of the scattered light. This effect is related to the anisotropy in the molecular polarizability, and to the dipole moment, but is not likely to lead to information that is not obtainable by

simpler means. The effect of a strong magnetic field, in place of  $F$ , is discussed. (auth)

17125

## NEW INTERPRETATIONS OF THE ORBITAL ENERGY

DIFFERENCES IN HEXAFLUORIDES. Chr. Klixbüll  
Jørgensen (Univ. of Denmark, Copenhagen). *Mol. Phys.* 3, 201-2(1960) Mar.

The absorption spectra of  $\text{ReF}_6$ ,  $\text{OsF}_6$ ,  $\text{IrF}_6$ , and  $\text{PtF}_6$  were recently reported by Moffitt et al. The narrow bands of these gaseous compounds in the infrared and red were successfully interpreted by ligand field theory as due to transitions from the lowest level to the other levels of M.O. configuration  $\gamma_5^n$ , assuming intermediate coupling. Values of  $B$ , derived from spin-allowed bands, and of the Lande parameter  $\zeta_{nd}$  and the orbital energy difference  $\Delta$  between the three equivalent  $\gamma_5$  and two equivalent  $\gamma_3$  orbitals are given. (B.O.G.)

17126

THE RESPONSE OF PLASTIC SCINTILLATORS TO HIGH-ENERGY PARTICLES. T. J. Gooding and H. G. Pugh (Atomic Energy Research Establishment, Harwell, Berks, Eng.). *Nuclear Instr. & Methods* 7, 189-92(1960) May. (In English)

The response of the plastic scintillator NE 102 is calculated for protons, deuterons, tritons, and alpha particles up to 160 Mev and it is shown how a linear counter may be constructed. The results of the calculation are tested experimentally for protons and deuterons. (auth)

17127

MOLECULAR DISTRIBUTION FUNCTIONS INVOLVING TWO TIMES. George H. Vineyard (Brookhaven National Lab., Upton, N. Y.). *Phys. Fluids* 3, 339-45(1960) May-June.

A kinetic theory of distribution functions for the condition of subsets of molecules in a classical fluid at two distinct times is developed. The treatment is a natural generalization of the kinetic theories of Yvon, Kirkwood, and Born and Green, and leads to differentio-integral equations linking distributions for  $q$  molecules and distributions for  $q + 1$  molecules. A generalization of the usual superposition approximation is suggested to truncate this infinite system of equations. Symmetries and other simple properties of the two-time distribution functions are explored, and it is shown that the pair correlation that determines inelastic scattering is a reduced form of the two-body positional distribution function. Explicit distributions are not calculated. (auth)

17128

EQUIVALENCE OF THE LANDAU AND FOKKER-PLANCK COLLISION TERMS. Jacob Enoch (Los Alamos Scientific Lab., N. Mex.). *Phys. Fluids* 3, 353-4(1960) May-June.

It is shown that the Landau collision term is equivalent to the Fokker-Planck type collision term as derived on the basis of the assumption that binary collisions predominate. (auth)

17129

THERMAL CONDUCTIVITIES OF RARE GAS MIXTURES. Edward A. Mason (Univ. of Maryland, College Park) and Hans von Ubisch (A. B. Atomenergi, Stockholm). *Phys. Fluids* 3, 355-61(1960) May-June.

Recent measurements of the thermal conductivities of all ten possible binary mixtures of the rare gases and of the ternary mixture  $\text{He}-\text{Kr}-\text{Xe}$  at 29 and 520°C are compared with theoretical calculations. Three calculations are carried out, based on: (1) rigorous kinetic theory, (2) an approximate formula which uses only conductivities of the

pure components, and (3) a new semiempirical formula which requires knowledge of the conductivity of one composition of binary mixture. The agreement is generally satisfactory and furnishes support for the usefulness and accuracy of the formulas. (auth)

17130

EXCESS PROPERTIES OF  $\text{H}_2-\text{D}_2$  LIQUID MIXTURES.

M. Lambert (Univ. of Brussels). *Phys. Rev. Letters* 4, 555-6(1960) June 1.

The heat of mixing ( $h_e$ ) and excess volume ( $v_e$ ) of  $\text{H}_2-\text{D}_2$  liquid mixtures were measured at 20.4°K. The mixing takes place adiabatically at constant pressure (1.5 atm.). The calorimeter temperature is measured by a platinum resistance thermometer and a Mueller bridge, by means of which 0.0002° changes may be observed. The measurements were made with liquids in ortho-para equilibrium at 20°K. The results are tabulated. (B.O.G.)

17131

## NEW THEORETICAL VALUE FOR THE LAMB SHIFT.

Arthur J. Layzer (Columbia Univ., New York). *Phys. Rev. Letters* 4, 580-2(1960) June 1.

Calculations have been made for the leading orders of  $\alpha(\alpha Z)^6/n^2(\alpha Z)$  and  $\alpha(\alpha Z)^6/n(\alpha Z)$ . Theoretical and experimental values of the Lamb shift in Mc/sec for H, D, and  $\text{He}^+$  are tabulated. The method used in the calculation is the free-propagator expansion, the algebraic expansion of the bound electron propagator or Green's functions in "powers" of the Coulomb potential. A presentation is given of the calculated results for arbitrary bound states and in particular for the 1S, 2S,  $2\text{P}_{1/2}$ , and  $2\text{P}_{3/2}$ . Details of the calculations of the two new orders are to be published, with more general results of a mathematical nature concerning properties of the free-propagator expansion connected with an expansion of self-energy in orders of  $(\alpha Z)$ . (B.O.G.)

17132

HIGHER ORDER TERMS IN THE LAMB SHIFT CALCULATION. H. M. Fried (Univ. of California, Los Angeles) and D. R. Yennie (Univ. of Minnesota, Minneapolis). *Phys. Rev. Letters* 4, 583-4(1960) June 1.

Following previously described techniques, the atomic energy level displacements of order  $\alpha(Z\alpha)^6 \ln^2(Z\alpha)mc^2$  have been calculated and yield a result in agreement with that of Layzer. An addition is introduced which corresponds to a change of gauge of the virtual photon defining one-photon Lamb shift and serves to remove spurious lower order contributions from each term of the combined sequence  $M_n = I_n + J_n$ . The first relativistic corrections to the lowest order Lamb shift [of order  $\alpha(Z\alpha)^5 mc^2$ ] and to hfs [of order  $\alpha(Z\alpha)E_H$ ] may be obtained by use of these techniques. The necessary matrix elements for hfs calculations can be read from those of similar Lamb shift effects. (B.O.G.)

17133

ELECTRONIC TRANSITION MOMENT VARIATION IN  $(\text{B}^1\Sigma \rightarrow \text{X}^1\Sigma)$  BANDS OF  $\text{BeO}$ .

N. R. Tawde and N. Sreedhara Murthy (Karnatak Univ., Dharwar, India). *Proc. Indian Acad. Sci., Sec. A* 51, 219-31(1960) Apr. (In English)

Accurate integrated intensity data of the bands of  $\text{BeO}$  ( $\text{B}^1\Sigma \rightarrow \text{X}^1\Sigma$ ) system were obtained experimentally by the technique of photographic photometry. With the use of Franck-Condon factors and r-centroids for the bands available from previous work, the relation of electronic transition moment  $R_e$  with internuclear separation  $r$ , was evolved. The vibrational transition probabilities were

corrected for the resulting variation of  $R_e$  with  $r$ . These corrected values were examined in relation to those under assumptions of constancy of  $R_e$  in conjunction with (i) mechanical anharmonicity and also (ii) mechanical harmonicity. (auth)

17134

A VARIATIONAL METHOD FOR THE GROUND STATE OF A BOSE FLUID. O. Penrose (Imperial Coll., London).

Proc. Roy. Soc. (London) A256, 106-14(1960) May 31.

A modification of the Rayleigh-Ritz variational principle is described which makes possible a calculation of the energy, wave function, and pair distribution function  $f_{12} = f(x_1, x_2)$  of a Bose fluid, such as liquid He<sup>4</sup>, at absolute zero. The assumptions made are: (i) two-body interactions with potential  $U_{ij}$ , (ii) trial wave functions of the form  $\prod_{ij} \exp \phi_{ij}$ , and (iii) the Kirkwood 'superposition' approximation. Under these approximations, the expectation energy is given. It is shown here that making  $E$  stationary with respect to independent variations in  $f$  and  $\phi$  corresponds to simultaneously applying the ordinary Rayleigh-Ritz principle and solving the Born-Green-Yvon integral equation for  $f$ . The method is illustrated by reproducing Bogolyubov's results for the case where  $U$  is small. The case where  $U$  is large must be dealt with numerically, but transformations for simplifying the computations are given here. (auth)

17135

ENERGY SPECTRUM OF PROTONS EMITTED FROM A FAST-NEUTRON-IRRADIATED HYDROGENOUS MATERIAL. Stanley Kronenberg and Harry M. Murphy, Jr. (Army Signal Research and Development Lab., Fort Monmouth, N. J.). Radiation Research 12, 728-35(1960) June.

A derivation is given of an empirical formula for the energy spectrum of protons leaving the surface of a fast-neutron-irradiated hydrogenous material, as a function of material constants and the incident neutron spectrum. The result derived is general and includes as a special case the well-known formula by Moyer for total number of protons. A computation is given for the proton spectrum from Plexiglas as a result of Watt spectrum neutron irradiation and as a result of monoenergetic neutron irradiation. (auth)

17136

SOME CHARACTERISTICS OF A DISCHARGE IN AN ION PUMP AND A MAGNETIC ION METER. E. M. Reikhrudel, G. V. Smirnitskaya, and M. N. Vasileva (Lomonosov Moscow State Univ.). Radiotekh. i Elektron. 5, 662-5(1960) Apr. (In Russian)

The characteristics and processes of electric discharge ignition in a cold cathode tube at low pressure in an external magnetic field are discussed. Previously, it was shown that a series of clearly expressed ionization regions can appear under certain discharge conditions. Moreover, the appearance of spatial charges and their reconstruction reflect the characteristics of the discharge. Volt-ampere characteristics of discharge and ion distribution rates near the cathode are presented. Processes accompanying discharge ignition in magnetic fields are correlated with vacuum spark processes. (tr-auth)

17137

ON THE PROBLEM OF THE ANALYSIS OF THE INTERACTION OF AN ELECTRON STREAM WITH A TRAVELING WAVE. M. B. Tseytin and E. M. Il'ina. Radiotekh. i Elektron. 5, 700-4(1960). (In Russian)

It is assumed that the high-frequency field intensity varies exponentially in the case of electron interactions

with traveling electromagnetic waves in assigned field approximations. However, such an approximation prevents the investigation of signal behavior in the initial region of the tube and the determination of initial losses. An attempt was made to further generalize by the assigned field method. The variations of high-frequency amplitudes along the tube axis are determined by the equation of active power balance. Under corresponding initial conditions the equation permits determining the distribution of the field amplitude along the tube axis and thus the evaluation of intensity. (R.V.J.)

17138

ON A MODEL OF CENTERS OF LUMINESCENCE IN ALKALI HALIDE CRYSTALLOPHOSPHORS. N. E.

Lushchik and Ch. B. Lushchik. Trudy Inst. Fiz. i Astron. Akad. Nauk Eston. S.S.R. No. 6, 5-62(1957). (In Russian)

An investigation was made of regularities in the spectra of absorption, excitation, and radiation of the homologous series of the crystals KCl-Ga, KCl-In, KCl-Sn, KCl-Tl, and KCl-Pb. A comparison was carried out of the centers of luminescence of these phosphors with the free ions Ga<sup>+</sup>, In<sup>+</sup>, Sn<sup>2+</sup>, Tl<sup>+</sup>, and Pb<sup>2+</sup>. By means of potential curves the characteristic features of the electron-vibrational transitions in the impurity centers were examined. For the investigated phosphors the amounts of energy of purely electronic transitions  $^1S_0 \rightarrow ^3P_0$  and  $^1S_0 \rightarrow ^3P_1$  were estimated, also the ratios of the power constants for the ground and the excited states. By means of the simple relation between the energy of electronic transition in the free ions and the energy of transitions in the centers of luminescence, established in the course of investigation, the spectral features of the phosphors KCl-Ga and KCl-Ge were predicted. The Dexter-Klick-Russell mechanism of optical quenching was examined as well as the criteria for the existence of luminescence at the impurity centers. The theoretical correlations obtained were applied to the description of the phosphors as spectral transformers. It is shown that deviations from Vavilov's law must occur. A conclusion is drawn that the centers of luminescence in alkali halide phosphors are the ions of the activator placed in the nodes of the crystal lattice, the centers interacting with the nearest ions of the basic substance (Seitz' model). (auth)

17139

ON THE PROBLEM OF MIGRATION OF ENERGY IN ALKALI HALIDE CRYSTALLOPHOSPHORS. Ch. B.

Lushchik, N. E. Lushchik, G. G. Liidya, and L. A. Teiss. Trudy Inst. Fiz. i Astron. Akad. Nauk Eston. S.S.R. No. 6, 63-81(1957). (In Russian)

An investigation of the excited absorption of  $\chi$ -irradiated phosphors of NaCl, KCl, and KBr, activated with In, Tl, Ag, Cu, Mn, Pb, and Cd was made. Bivalent ions serve as effective trapping centers for the electrons. No diminution was observed in the activator absorption in the phosphors activated with In and Tl after the  $\chi$  irradiation. The conclusion was drawn that the ions of the activator cannot serve as trapping centers for the holes, and the hole mechanism of migration of energy from the basic substance to the impurity centers is unsuitable for the alkali halide phosphors. The exciton mechanism of energy migration was considered. In KI-In an immediate production of excitons, localized on the ions In<sup>+</sup>, was observed. The excitons are subsequently annihilated, transmitting their energy to the In<sup>+</sup> ions. In their interaction with bivalent impurities, the excitons are dissociated (electrons are localized on the ions of impurities and free holes on the cation vacancies). In KCl-Ca, Ag irradiating action of  $\chi$

rays has been observed. The migration of energy in alkali halide phosphors is carried out most likely by means of the exciton mechanism suggested by Seitz and others.

(auth)

#### 17140

A COMPLEX INVESTIGATION OF THE TRAPPING CENTERS IN ALKALI HALIDE CRYSTALLOPHOSPHORS WITH DIVALENT IMPURITIES. F. N. Zaitov and V. Ya. Kark. Trudy Inst. Fiz. i Astron. Akad. Nauk Eston. S.S.R. No. 6, 82-125(1957). (In Russian)

An investigation was made of the influence of bivalent impurities  $\text{Ca}^{2+}$ ,  $\text{Sr}^{2+}$ , and  $\text{Cd}^{2+}$  upon the inertia features of the alkali halide crystallophosphors  $\text{NaCl}$ ,  $\text{KCl}$ , and  $\text{KBr}$ . It is shown that the Z-centers, formed by the bivalent impurities, play an essential part in the recombination luminescence of the crystals. Luminescence appears both at the thermal luminescence and optical flash of electrons from the  $Z_1$ -levels. In the optical flash there also appear M-centers. The relative quantum output of the optical flash in the F,  $Z_1$ , and M-bands was measured. The quantum output of the optical flash for the  $Z_1$  and M-bands is less than the quantum output of the flash in the F-band. The bivalent impurities influence the conditions of filling the trapping levels by the electrons and holes. This leads to an increase of stored electrons at F-levels and of holes at  $V_2$ -levels; to a decrease of electrons stored at M-levels; and to a nearly complete cessation of electron accumulation at R- and N-levels. The presence of bivalent impurities leads also to a change in the thermal and optical stabilities of the color centers. It is shown that in alkali halide phosphors, under certain conditions, an essential part is played by ionic processes. The spectrum of the local trapping levels depends on the thermal processing of the crystal and in some cases changes in the process of relaxation. A new method is suggested and carried out, that of direct experimental determination (by the combined methods of thermo-optical stimulation and thermal bleaching) of the connection between the brightness of the optical flash  $I_\lambda$  and the number of the stored electrons  $n$  (determining the order of the reaction of the optical flash.) (auth)

#### 17141

ON ONE OF THE METHODS OF INVESTIGATING DEEP TRAPPING LEVELS. K.-S. K. Rebane. Trudy Inst. Fiz. i Astron. Akad. Nauk Eston. S.S.R. No. 6, 126-31(1957). (In Russian)

A new method is described for investigating trapping centers. The method consists of studying the variation of the light sum of the luminescence rise  $S_p$ , which takes place as a result of the thermal stimulation of the light sum stored in the phosphor by the previous excitation. The method makes it possible to investigate the features of a number of trapping levels which cannot be detected by thermal luminescence or by the measurement of excited absorption. For an illustration of the method the dependence of the light sum on the thermal stimulation of  $\text{ZnS-Cu}$ ,  $\text{Ni}$  was measured. A comparison with results obtained by the method of thermo-optical stimulation shows a coincidence of the results: in either case it is concluded that in  $\text{ZnS-Cu}$ ,  $\text{Ni}$  there are levels which are discharged at a temperature of  $\sim 100^\circ\text{C}$ . (auth)

#### 17142

ALKALI HALIDE PHOSPHORS ACTIVATED WITH INDIUM. N. E. Lushchik. Trudy Inst. Fiz. i Astron. Akad. Nauk Eston. S.S.R. No. 6, 149-68(1957). (In Russian)

An investigation was made of the spectra of absorption, excitation, and luminescence of  $\text{NaCl-In}$ ,  $\text{KCl-In}$ ,  $\text{KBr-In}$ , and  $\text{KI-In}$ . The absorption, excitation, and luminescence

bands were compared with the electronic transitions  $^1\text{S}_0 \rightarrow ^3\text{P}_0$ ,  $^1\text{S}_0 \rightarrow ^3\text{P}_1$ ,  $^1\text{S}_0 \rightarrow ^3\text{P}_2$ , and  $^1\text{S}_0 \rightarrow ^1\text{P}_1$  in the free  $\text{In}^+$  ions, and with the absorption of  $\text{InCl}$ . The thermal luminescence and the optical flash in the F-band in the x-irradiated phosphor  $\text{KCl-In}$  were investigated. The output of the optical flash is approximately ten times less than the output of the fluorescence excited directly in the  $\text{In}^+$  ions. The activator absorption in  $\text{KBr-In}$  after x irradiation decreases very little. (auth)

#### 17143

TEMPERATURE QUENCHING IN CERTAIN ALKALI HALIDE CRYSTAL PHOSPHORS. K. K. Shvarts. Trudy Inst. Fiz. i Astron. Akad. Nauk Eston. S.S.R. No. 7, 153-92(1958). (In Russian)

The quantum yield of luminescence, and the temperature and concentration factors on which it depends were studied for phosphors of  $\text{NaCl}$ ,  $\text{KCl}$ ,  $\text{KBr}$ , and  $\text{KI}$ , activated by mercury-like ions ( $\text{Ti}^+$ ,  $\text{Pb}^{2+}$ ,  $\text{In}^+$ , and  $\text{Sn}^{2+}$ ) and copper. The spectral characteristics of the luminescence centers of certain phosphors were investigated. (auth)

#### 17144

PHOTOSTIMULATION OF  $\text{ZnS-Cu}$  PHOSPHORS. K.-S. K. Rebane. Trudy Inst. Fiz. i Astron. Akad. Nauk Eston. S.S.R. No. 7, 357-60(1958). (In Russian)

Some data are presented for the rise curve of the photo-stimulation in  $\text{ZnS-Cu}$  phosphors, and the conductivity sign, conditioned by infrared light, is shown to be identical for both stimulation bands (750 and 1250 m $\mu$ ). (auth)

#### 17145

AN INVESTIGATION OF THE DEPENDENCE OF THE LUMINESCENCE CHARACTERISTIC OF  $\text{ZnS}$  PHOSPHORS ON THE INTENSITY OF EXCITING LIGHT. K.-S. K. Rebane. Trudy Inst. Fiz. i Astron. Akad. Nauk Eston. S.S.R. No. 8, 105-33(1958). (In Russian)

It is shown that under the influence of infrared light the region of nonlinear dependence of luminescence on excitation intensity shifts toward higher excitation intensities. It is not possible to quench luminescence completely by means of infrared light. It was found that upon increasing excitation intensity the light sum value increases at first and then begins to decrease. Changes in excitation intensity are accompanied by changes in the rapidity of rise process and the decay law. The law of temperature quenching for that part of luminescence which cannot be quenched by infrared light differs from the law of temperature quenching for the remainder of the luminescence. Existing theories of non-linearity were examined on the basis of the data obtained. It is shown that the theory based on the model with two classes of recombination centers, representing only electronic and hole processes, is generally capable of explaining satisfactorily the phenomenon of non-linearity. Experimental data obtained in this work indicate that this model does not take into account all the essential processes occurring in the phosphor. The hypothesis is suggested that sensitized processes exist in the phosphor and the possibility is shown of accounting for experimental data by assuming that sensitized processes occur in  $\text{ZnS}$  phosphors alongside hole and electronic processes. (auth)

#### 17146

SENSITIZED LUMINESCENCE IN ALKALI HALIDE CRYSTALS ACTIVATED WITH MERCURY-LIKE ACTIVATORS AND MANGANESE. K. K. Schwartz and U. A. Zirnitis. Trudy Inst. Fiz. i Astron. Akad. Nauk Eston. S.S.R. No. 11, 3-28(1960). (In Russian)

The migration of energy between the impurity centers in

alkali halide crystal phosphors is discussed. In the phosphor KCl-Tl, Pb the luminescence of the  $Pb^{2+}$  ions may be observed at the excitation of the  $Tl^{+}$  ions. The energy transfer is conditioned by reabsorption. In the KCl and NaCl phosphors the possibility of energy transfer from  $Tl^{+}$ ,  $In^{+}$ ,  $Ga^{+}$ ,  $Pb^{2+}$ , and  $Sn^{2+}$  ions to  $Mn^{2+}$  ions was examined. The effective transfer of energy to  $Mn^{2+}$  ions was observed from  $Pb^{2+}$  ions in KCl and from  $Pb^{2+}$ ,  $Tl^{+}$ , and  $In^{+}$  ions in NaCl. It is shown that the sensitized luminescence phenomenon in the KCl-Pb, Mn and NaCl-Pb, Mn systems is due to the fact that the local concentrations of Pb and Mn in some regions of the crystal considerably exceed average concentrations. The effect of sensitization in these systems greatly depends on the physicochemical state of the phosphor. (auth)

17147

SPECTRUM CHARACTERISTICS OF THE SUBLIMATE PHOSPHOR  $CsHal-Tl$ . A. F. Malysheva. Trudy Inst. Fiz. i Astron., Akad. Nauk Eston. S.S.R. No. 11, 29-48(1960). (In Russian)

Excitation and emission spectra of the sublimate phosphors on the basis of thallium-activated cesium halide salts were investigated. It is concluded that there exists in these phosphors at least two types of luminescence centers with differing characteristics. The excitation bands are connected with the electronic transitions in the activator. The influence of an allogenic anion, introduced with the activator, upon the spectral characteristics of the luminescence centers of the  $CsBr-Tl$  Hal phosphor was examined. (auth)

17148

ON THE INFLUENCE OF SOME PHYSICO-CHEMICAL FACTORS ON THE OPTICAL FLASH OF LUMINESCENCE IN ALKALI HALIDE PHOSPHORS. P. A. Hellenurme. Trudy Inst. Fiz. i Astron., Akad. Nauk Eston. S.S.R. No. 11, 116-29(1960). (In Russian)

The influence of physicochemical factors on the spectra of the KCl-Tl phosphor was investigated. It is shown that changing the activator concentration causes a redistribution of the band intensities in the optical flash stimulation spectrum, the different traps having different optimum concentrations of the activator. The spectral sensitivity of KCl-Tl toward infrared is decreased by adding divalent nonactivating impurities and increased by the plastic deformation of the crystal. The measured optical flash stimulation spectra in the homologous series of thallium-activated alkali halide phosphors are presented. (auth)

17149

THE INTERACTION OF EXCITONS WITH DEFECTS IN ALKALI HALIDE CRYSTALS. G. G. Lihdy. Trudy Inst. Fiz. i Astron., Akad. Nauk Eston. S.S.R. No. 11, 187-8 (1960). (In Russian)

The interaction of excitons with various defects in crystals was studied in order to determine the exciton mechanism of external and internal photoeffect, luminescence, and photochemical transformations in alkali halide crystals. A simultaneous appearance of vacancy centers and electron F centers was observed in previously x rayed and optically discolored  $KBr-Sr$  and  $KCl-Sr$  crystals at 100°K. Interactions of excitons with divalent ions ( $Pb^{2+}$ ,  $Sn^{2+}$ ,  $Ge^{4+}$ , and  $Mn^{2+}$ ) in  $KBr$  transforms them into single valences. Photochemical spectra show that the maximum F center formations in  $KCl-Sr$ ,  $Tl$ , and  $KBr-Pb$  and transformations of  $P^{4+}$  and  $Pb^{2+}e$  correspond to the excitation in the exciton band. Ordinarily several parallel reactions with various capture centers are present in crystals. It is

possible to induce exciton interactions with prevailing types of defects in the crystal. (R.V.J.)

17150

THE DEPENDENCE OF LUMINESCENCE YIELD ON THE CONCENTRATION TO ACTIVATOR IN ALKALI-HALIDE PHOSPHORS ACTIVATED BY SILVER. L. A. Rebane. Trudy Inst. Fiz. i Astron., Akad. Nauk Eston. S.S.R. No. 11, 193-6(1960). (In Russian)

Absorption spectra, excitation, emission, and luminescence yield in the concentrated phosphors  $NaCl-Ag$ ,  $NaBr-Ag$ , and  $KCl-Ag$ , with activator from 0.01 to 3 mol. % (in melt), were investigated. (R.V.J.)

17151

THE INFLUENCE OF THE CONCENTRATION OF COPPER ON SOME SPECTRAL PROPERTIES OF  $ZnS-Cu$ ,  $Cl$  PHOSPHORS. K.-S. Rebane. Trudy Inst. Fiz. i Astron., Akad. Nauk Eston. S.S.R. No. 11, 197-8(1960). (In Russian)

The influence of Cu concentration in  $ZrS-Cu$  phosphors on the emission and excitation spectra was studied in specimens with  $Cu 10^{-2} g/g$  with blue and green bands. (R.V.J.)

17152

THE PHOTOELECTRIC POLARIZATION OF ZINC AND CADMIUM SULPHIDE MIXED PHOSPHORS. U. Kh. Nym and A. K. Aidla. Trudy Inst. Fiz. i Astron., Akad. Nauk Eston. S.S.R. No. 11, 199-200(1960). (In Russian)

Photoelectric polarization in the mixed phosphor  $ZnS-CdS-Cu$  with 8, 18, 25, 35, and 45%  $CdS$  was investigated. (R.V.J.)

17153

THE SCINTILLATION BEHAVIOR OF SOME INORGANIC PHOSPHORS AT LOW TEMPERATURE. R. Langkau (I. Institut f. Experimentalphysik, Hamburg). Z. Naturforsch. 15a, 364(1960) Apr. (In German)

The fluorescence decay of the scintillations excited by 4-Mev  $\alpha$  particles at the temperature of liquid nitrogen (-195°C) was investigated on the inorganic phosphors  $ZnS(Ag)$ ,  $ZnO$ , and  $CaWO_4$ . The results were compared with those obtained at room temperature. Both decay curves are satisfactory under the assumption that the scintillation course is composed of several (maximum three) exponentially decaying components. The intensity ratio of the long component does not agree with the tabulated values since in the time measurement scale selected, the decay in the beginning of the curve occurs so rapidly that only a coarse adjustment of both curves to the same initial intensity is possible. (J.S.R.)

17154

IONIZATION OF GASES BY NEGATIVE IONS. Ya. M. Fogel', A. G. Koval', and Yu. Z. Levchenko. Zhur. Eksppl. i Teoret. Fiz. 38, 1053-60(1960) Apr. (In Russian)

The total effective cross sections of formation of positive ions as a result of collisions of 10 to 50 kev  $H^-$  ions with He, Ne, Ar, Kr, and Xe atoms and  $H_2$ ,  $N_2$ , and  $O_2$  molecules, and as a result of collisions between  $O^-$  ions of the same energies with inert gas atoms and  $H_2$  and  $O_2$  molecules are measured. The ionization cross sections for  $H^-$  and  $H^+$  ions are compared. (auth)

17155

PROCEEDINGS OF THE FOURTH INTERNATIONAL CONFERENCE ON IONIZATION PHENOMENA IN GASES, UPPSALA, 17-21 AUGUST 1959. VOLUMES I AND II. N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. 1225p. \$34.50.

227 papers are included; separate abstracts have been

prepared for 211. Abstracts for the remaining 16 have previously appeared in NSA. (M.C.G.)

## 17156

RECENT ADVANCES IN THE STUDY OF COLLISION PROCESSES IN GASES. Wade L. Fite (General Atomic Div., General Dynamics Corp., San Diego, Calif.). p.3-13 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Recent advances in the study of two-particle collision phenomena at low and intermediate energies include the measurement of the cross sections for the elastic and inelastic scattering of electrons from atomic hydrogen, experimental tests of the relative importance of direct versus exchange collisions in low-energy electron scattering, and the measurement of the ionization cross section of atomic hydrogen on electron impact. The study of electron collisions with molecules has continued to be an active area of research. The study of collisions between heavy particles has resulted in new information on charge transfer, ionization and negative-ion stripping, fragmentation, large-angle scattering, collisional de-excitation of metastable mono-electronic systems, and ion-exchange collisions. (M.C.G.)

## 17157

STUDY OF INELASTIC COLLISIONS OF ELECTRONS WITH ATOMS AND MOLECULES USING THE TRAPPED-ELECTRON METHOD. G. J. Schulz (Westinghouse Electric Corp., Pittsburgh). p.14-18 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The inelastic collisions of electrons with atoms and molecules can be studied by the trapped-electron method. In this method, a beam of electrons traverses a collision chamber and those electrons which have lost a portion of their initial energy in an inelastic collision are trapped in a potential well and collected on a separate electrode. The well depth determines the energy range over which inelastically scattered electrons are collected. Data obtained at small well depths yield the slope of the excitation functions near threshold. With a large well depth, (3 volts), one can study the excitation function from its onset to 3 ev above onset. The shape of the excitation function in helium obtained by this method is in excellent agreement with data on the excitation function obtained by other methods. The trapped-electron method has been applied to a study of inelastic energy loss processes in molecules. The most striking result obtained to date is the observation of a large inelastic peak in nitrogen and in carbon monoxide at 2.3 and 1.7 ev, respectively. This phenomenon can be discussed in terms of the formation of a temporary negative ion state of  $N_2$  or  $CO$  and subsequent decay into various vibrational levels of the neutral molecule. It is found that the cross section for exciting low-lying vibrational states via this process is much larger than that for high-lying states. Neither  $O_2$  nor  $H_2$  show a similar behavior at low energies. (auth)

## 17158

"IONIZATION" OF THE HYDROGEN NEGATIVE ION. Sydney Geltman (National Bureau of Standards, Washington, D. C.). p.19-22 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The cross section for the detachment of an electron from  $H^-$  by electron impact has been calculated from threshold (0.75 ev) to 75 ev. The Born-Oppenheimer approximation was used to obtain the direct and exchange amplitudes for the singlet-singlet and singlet-triplet transitions from the initial  $^1S_0$  state of  $H^-$  to the final free state. Atomic wave functions were used which have previously yielded an accurate photodetachment cross section curve. The integration of the differential cross section over all angles of the final two free electrons and over their distribution of excess energy was performed with the aid of a digital electronic computer. A correction was introduced for the reduction in detachment cross section due to the long range Coulomb repulsion exerted on the incident electron by the  $H^-$  ion. The resulting section has a broad maximum of  $700 \pi a_0^2$  centered at about 45 ev, about  $10^3$  times as large as that for ionization of the  $H$  atom. This large value can be understood in terms of the weaker binding in negative ions than in neutral atoms. (auth)

## 17159

COLLISIONS OF HYDROGEN IONS WITH HYDROGEN ATOMS. Wade L. Fite (General Atomic Div., General Dynamics Corp., San Diego, Calif.). p.23-7 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The cross sections for a number of processes involving the free hydrogen atom and various ions have been determined over an ion energy range from 50 ev to 40 kev using modulated-atomic-beam techniques. In these experiments, a thermal-dissociation source produces a hydrogen atom beam which is mechanically modulated at an audio frequency. The atom beam is crossed by a d-c ion beam and detection of a final product of the interaction is made. By using such modulation techniques, the signal associated with the interaction of the two beams is distinguishable from the much larger signal associated with the interaction of the ion beam and the residual gas in the vacuum chamber, because the former occurs at the modulation frequency and in specified phase. Absolute cross-section values are determined by comparison with known ion-molecule and electron-atom collision cross sections. For collisions of  $H^+$  and  $H_2^+$ , slow proton and electron signals are used to deduce the cross sections for both charge transfer and ionization or ion impact. For collisions of  $H^-$  on  $H$ , slow  $H^-$  and electron signals yield both charge-transfer and electron-stripping cross sections. The results of these measurements are presented and compared with available theoretical work. (auth)

## 17160

CHARGE TRANSFER OF MULTIPLY CHARGED IONS. J. B. Hasted, J. T. Scott, and A. Y. J. Chong (University Coll., London). p.34-40 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Experimental data are presented on the charge degradation of multiply charged krypton ions ( $Kr^{n+}$  to  $Kr^{1+}$ ) in neon in the energy region 50 to 8000 ev. The factors governing the partial charge transfer process  $n \ 0 \ (n-1), 1$ , i.e.,  $Kr^{n+} + Ne \rightarrow Kr^{(n-1)+} + Ne^+$ , are discussed, and the experimental data reviewed in the light of calculations made by Boyd and Moiseiwitsch for a single pseudo-crossing of potential energy curves. The reactions 2011 and 3021 are in agreement with theory. Cross sections are measured in

the single collision region, but higher pressure data are interpreted consistently as successive reactions. The degradation of the quadruply charged ion  $\text{Kr}^{4+}$  to  $\text{Kr}^{3+}$  is interpreted tentatively as a 4032 transfer ionization reaction, and a similar degradation of  $\text{Kr}^{5+}$  to  $\text{Kr}^{4+}$  is observed. (auth)

## 17161

CAPTURE OF ELECTRONS BY MULTIPLY CHARGED IONS. N. V. Fedorenko, I. P. Flaks, L. G. Philippenko, and E. S. Solov'ev (Physical Technical Inst., Leningrad). p.41-6 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Measurements of cross sections for electron capture by  $\text{Ne}^+$ ,  $\text{Ne}^{2+}$ ,  $\text{Ne}^{3+}$ ,  $\text{Ar}^+$ ,  $\text{Ar}^{2+}$ ,  $\text{Kr}^+$ ,  $\text{Kr}^{2+}$ ,  $\text{Kr}^{3+}$ ,  $\text{Xe}^+$ ,  $\text{Xe}^{2+}$  ions accelerated by a voltage 2 to 30 kev making single collisions with the atoms of inert gases were made. For the measurement of cross sections the mass spectrometer method was used, which gives the possibility of a separate investigation of complete and partial neutralization of the ions involving the capture of a different number of electrons. The angular distribution of the ions and of the fast atoms arising as a result of capture, was also investigated. It was found from the scattering data that the distances of approach of the colliding atomic particles during the processes of capture, are a few Angstrom units. (auth)

## 17162

IONIZATION OF INERT GASES BY PROTONS. N. V. Fedorenko, V. V. Afrosimov, R. N. Il'in, and E. S. Solov'ev (Physical-Technical Inst., Leningrad). p.47-51 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Measurements of the total cross section for the ionization of inert gases by protons of energy from 5 to 190 kev were carried out. It was found that for all inert gases in this energy range the total cross section for ionization reaches a maximum when the velocity of protons is about  $3$  to  $5 \times 10^8$  cm/sec. For helium the cross sections beyond the maximum obtained experimentally agree satisfactorily with those calculated by Mapleton using the Born approximation. Cross sections for the formation of multiply charged ions in He ( $\text{He}^+$ ,  $\text{He}^{2+}$ ), in Ne ( $\text{Ne}^+$ ,  $\text{Ne}^{2+}$ ,  $\text{Ne}^{3+}$ ), in Kr ( $\text{Kr}^+$ ,  $\text{Kr}^{2+}$ ,  $\text{Kr}^{3+}$ ,  $\text{Kr}^{4+}$ ), and in Xe ( $\text{Xe}^+$ ,  $\text{Xe}^{2+}$ ,  $\text{Xe}^{3+}$ ,  $\text{Xe}^{4+}$ ,  $\text{Xe}^{5+}$ ) were also measured. It was found that the formation of multiply charged (or secondary) ions takes place at velocities below the threshold velocity for ionization by electron impact with the removal of one electron. In some cases maxima are observed on the curves showing the dependence of the cross section for the formation of multiply charged ions with charge  $n$ , upon the velocity of the protons. It is assumed that these maxima correspond to maximum values of the cross sections for the ionization with capture of one electron and the release of  $n-1$  electrons. (auth)

## 17163

ELASTIC AND INELASTIC COLLISIONS OF LOW-ENERGY NEGATIVE IONS IN GASES. E. E. Muschitz, Jr. (Univ. of Florida, Gainesville). p.52-6 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Collision cross sections for both elastic and inelastic collisions of 4 to 400 ev  $\text{O}^-$  and  $\text{O}_2^-$  ions in oxygen have

been determined. The method of measurement has been further improved over that used previously in this laboratory. A momentum-analyzed, cylindrical beam of ions enters a collision chamber containing the scattering gas at pressures of  $1$  to  $4 \times 10^{-3}$  mm Hg. Elastically scattered ions are distinguished from slow charged particles formed in inelastic collisions by means of a retarding potential applied between a cylindrical grid surrounding the beam and an outer collecting cylinder. Results obtained with this apparatus show that the electrons produced in electron detachment collisions have energies considerably higher than thermal and that their energy varies from one system to another. The results indicate also that charge exchange makes a large contribution to the inelastic scattering of  $\text{O}_2^-$  in  $\text{O}_2$ , particularly at low incident ion energies. Single-term, inverse-power interaction potentials are fitted to the elastic scattering data in the low energy range. These are interpreted in terms of the probable nature of the interaction forces, and are compared with previous results for the scattering of  $\text{H}^-$  ions in the rare gases. (auth)

## 17164

HIGH EVIDENCE FOR GAS IONIZATION EFFECTS BY LOW ENERGY ION IMPACT. H. Fetz (Univ. of Würzburg, Ger.). p.57-9 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

In our device, ions of inert and molecular gases are accelerated by the high electric field ( $X/p$  is in the order of 100 to 500 V/cm Torr) surrounding a thin rod within a concentric cylinder. An electron liberation is observed which is strongly dependent on  $X/p$  and on the gas-pressure. Calculations show that the electron yield observed may result from a gas ionization process, effective with relatively low energy ions. (auth)

## 17165

INTERACTIONS BETWEEN 5-24 keV IONS OR NEUTRALS AND GAS MOLECULES. Th. J. M. Sluyters, E. de Haas, and J. Kistemaker (F.O.M.-Laboratorium voor Massaspectrografie, Amsterdam). p.60-4 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The cross sections associated with ionization, electron charge exchange, and electron loss were measured for Ar and  $\text{Ar}^+$  in  $\text{H}_2$ , He, Ne, Ar, Kr, and Xe. The ionization cross sections for ions are about 35% higher than the values for the neutrals in the same gases. The distance of interaction is roughly calculated from an exponential increase of the ionization cross-section with energy. Several spectral features arising from passage of  $\text{Ar}^+$  ions through noble gases were investigated in the spectral range 1600 to 6000 Å. (auth)

## 17166

IONIZATION OF HIGH VELOCITY ALKALI ATOMS BY COLLISIONS WITH ATOMS OF THE INERT GASES. V. M. Dukleskii (Dukelsky), J. F. Bydin, and A. M. Bukteev (Physico-Technical Inst., Academy of Sciences, Leningrad). p.65-8 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The cross sections for the loss of an electron by high velocity Na, K, Rb, and Cs atoms of energy ranging from

300 to 2,000 ev in single collisions with He, Ne, Ar, Kr, and Xe atoms were measured, and found to have values of the order of  $10^{-20}$  to  $10^{-18}$  cm<sup>2</sup>. In certain cases the experimental results are consistent with the general theoretical predictions concerning slow inelastic collisions between atomic systems. (auth)

## 17167

MOLECULAR IONS. Robert N. Varney (Washington Univ., St Louis). p.69-71 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Nitrogen ions observed in drift velocity studies showed unusual behavior in that they seemed to alternate between  $N_2^+$  and  $N_4^+$  many times during a single crossing from anode to cathode. This behavior is now analyzed by thermodynamic means in the same way that the thermal dissociation of molecular gases is treated. The analysis then yields certain interesting data. First, a "temperature" of the ions as a function of  $E/p_0$ , the ratio of field strength to pressure, is obtained. It is  $\theta = 12.5 E/p_0$ , with  $\theta$  in °K and  $E/p_0$  in V cm<sup>-1</sup> (mm Hg)<sup>-1</sup>. Second, the binding energy of the  $N_4^+$  ion is found to be about 0.5 ev. Third, the equilibrium point of the reaction  $N_4^+ = N_2^+ + N_2$  is seen to depend linearly on the gas pressure. The last result in particular gives valuable advice for further experimental studies. (auth)

## 17168

ELECTRON ATTACHMENT AND COLLISION FREQUENCIES IN OXYGEN AND NITROGEN. Manfred A. Biondi (Westinghouse Electric Corp., Pittsburgh). p.72-8 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Improved electron drift tubes and circuitry have permitted measurements of electron drift velocities and attachment coefficients at considerably lower values of  $E/p$  (electric drift field/gas pressure) than previously were attained. The electron attachment coefficients determined by Chanin, Phelps, and Biondi for average electron energies  $\bar{U} > 1.5$  ev are in reasonable agreement with earlier work, in that a two-body attachment process is observed. However, for  $\bar{U} < 1$  ev and pressures in the range  $\approx 5$  to 50 mm Hg, the attachment exhibits a three-body pressure dependence, contrary to conclusions drawn from previous work. The three-body reaction exhibits a maximum coefficient  $K = 5 \times 10^{-30}$  cm<sup>6</sup>/sec at  $\bar{U} \approx 0.09$  ev. At thermal energy  $T_e = T_{gas} = 300^\circ\text{K}$  the value has fallen to  $\approx 2.8 \times 10^{-30}$  cm<sup>6</sup>/sec. The effects of other gases such as nitrogen and helium acting as the third body in the attachment reaction have been studied. The experimental results are compared with the Bloch-Bradbury theory of electron attachment and found to disagree in a number of points. Electron drift velocity measurements by Pack and Phelps have been carried out in nitrogen over the range  $0.0005 < E/p < 20$ . Sufficiently low values of  $E/p$  were attained to permit thermal equilibrium measurements for gas temperatures of 77°, 300°, and 373°K. The elastic collision cross sections deduced from these studies are in agreement with earlier microwave afterglow measurements. (auth)

## 17169

THERMAL ELECTRON ATTACHMENT COEFFICIENT OF OXYGEN MOLECULES NEAR A NUCLEAR BURST. Charles W. Dubs and Hari K. Sen (Air Force Cambridge Research Center, Bedford, Mass.). p.79-83 of "Proceed-

ings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The three-body attachment coefficient  $K$  of thermal electrons to oxygen molecules is determined by comparison of calculated and measured values of attenuation of telemetering signals in the vicinity of a nuclear burst in the upper troposphere at time  $t_1 = 0.01$  sec. The result,  $K = 7 \times 10^{-30}$  cm<sup>6</sup>/sec, is about four times the values obtained at Westinghouse and at Oak Ridge and is consistent with the values obtained by Kaiser from the observed decrease in echo rate of long enduring echoes from meteor trails (height about 80 km). (auth)

## 17170

VOLUME RECOMBINATION AND DIFFUSION IN AFTERGLOWS. Ernest P. Gray (Johns Hopkins Univ., Silver Spring, Md.) and Donald E. Kerr (Johns Hopkins Univ., Baltimore). p.84-8 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

To assess the applicability of the microwave method for determining recombination coefficients in the presence of diffusion, an exact numerical solution of the partial differential equation governing the decay of electron concentration in an afterglow was obtained. The results were applied to discuss measurements for argon, neon, and helium. (auth)

## 17171

ELECTRON REMOVAL PROCESSES IN THE AFTERGLOWS OF MICROWAVE DISCHARGES IN ARGON AND OXYGEN. M. C. Sexton, M. J. Mulcahy, and J. J. Lennon (The University, Liverpool). p.94-8 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Microwave techniques are employed to measure the decline of electron density in the afterglows of pulsed discharges in argon and oxygen. In argon the effects of different probing signal strengths on the thermal afterglow were studied and the maximum permissible strength found to be approximately 10  $\mu\text{W}$ . In oxygen attachment measurements at thermal energies yielded an apparent cross-section of  $1.5 \times 10^{-22}$  cm<sup>2</sup> at pressures of 5.2 and 20.2 mm Hg. (auth)

## 17172

MICROWAVE DETERMINATIONS OF AFTERGLOW TEMPERATURES AND ELECTRON COLLISION FREQUENCIES IN NITROGEN. Domenico Formato and Aldo Gilardini (Sindel S.p.A., Rome). p.99-104 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The electron collision probabilities in nitrogen, measured by different authors with microwave techniques, show large discrepancies. A possible explanation is that the electron mean energy in the afterglow is in some experiments much larger than the thermal value. A method is described for determining the afterglow electron temperatures from microwave noise measurements. With this method it was found that in the nitrogen afterglow of a d-c pulsed discharge in a long glass tube the electron temperature is, in fact, much higher than room temperature, also

at post-discharge times larger than 100  $\mu$ sec. A possible reason for these high temperatures is the presence of energetic electrons coming from ionizing metastable collisions; this continuous source of electrons in the afterglow is also required to explain the observed slow electron density decay. (auth)

## 17173

SURVEY OF RECENT WORK ON CURRENT GROWTH. H. Raether (Universität, Hamburg). p.105-14 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The most important knowledge gained by recent work is the mechanisms by which current growth proceeds in the preparation for breakdown. Current growth may be started by one or a great number of electrons. The current of an avalanche, started by one electron leaving the cathode, is composed of electron and ionic components. A study of the electron component in methane shows that it grows exponentially with the calculated time constant  $1/\alpha v$ . If the amplification of the avalanche is increased, the probability grows that sufficient photons are emitted by the avalanche to produce new electrons at the cathode. It was observed in many cases that if the current reaches a certain limit the series of avalanches does not break down but the current grows more than linearly. Work on current growth with strong illumination is also discussed. (M.C.G.)

## 17174

A STUDY OF THE ELECTRON COMPONENT OF ELECTRON AVALANCHES. L. Frommhold (Universität, Hamburg). p.115-18 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

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## 17175

SPACE CHARGE DISTORTION IN THE SIMULTANEOUS DEVELOPMENT OF ELECTRON AVALANCHES IN UNIFORM FIELDS. D. W. Swan (Queen Mary Coll., London). p.119-23 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

A theoretical study of the simultaneous development of a large number of electron avalanches in uniform fields is presented, which is applicable at high pressures where the equation  $\alpha/p = A \exp(BE/p)$  is approximately true. Earlier calculations using a similar model have assumed  $\alpha$  to be a linear function of  $E$ , and although simpler mathematically, the results do not apply for the pressure region in which space charge is of importance, i.e., low  $E/p$ . Assuming the applied voltage remains constant, it is shown that the average ionization first decreases and then increases very rapidly. The fast rise is a consequence of the chosen form of  $\alpha$  as function of  $E$ , and therefore it did not appear in the earlier calculations. A breakdown criterion can also be formulated which is similar to the Townsend threshold in that the charge tends to infinity as the gap is increased at constant  $E/p$ . Finally, the growth of a single electron avalanche ahead of the bulk of the electrons is shown to be greatly enhanced giving conditions suitable for breakdown more rapidly than in the undistorted field. (auth)

## 17176

AVALANCHES OF VERY HIGH AMPLIFICATION. H. Raether (Universität, Hamburg). p.124-6 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The study of single avalanches of high carrier numbers  $n$  in vapors shows several new features: If  $10^6 < n < 10^8$  the increase of  $n$  with  $x$  goes slower than exponentially. This comes from the space charge of the positive ions retarding the electrons. If  $n$  approaches  $\sim 10^8$  the primary avalanche is followed by a steeply rising current ("streamer"). The probability of this phenomenon and the time between the avalanche and this current increase with  $n$  and the applied electrical field. (auth)

## 17177

A METHOD FOR DETERMINING THE IONIZATION COEFFICIENT BY THE STATISTICS OF AVALANCHES. Hans Schlumbohm (Universität, Hamburg). p.127-30 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The ionization coefficient  $\alpha$  was determined by the statistical distribution of the avalanche size. The values of  $\alpha$  are calculated from the mean value of measured distributions. The inaccuracy of the values of  $\alpha$  is less than 2%, as a detailed experimental study of the distribution has shown. Thus this method is just as accurate as that of Townsend. Values of  $\alpha/p$  were determined at different  $E/p$ -ranges ( $p$  = gas pressure,  $E$  = electrical field-strength) for seven organic vapors. This method can also be applied in a modified form to electro-negative gases such as oxygen. (auth)

## 17178

FUNDAMENTAL PROCESSES IN THE TEMPORAL GROWTH OF IONIZATION. F. Llewellyn Jones and Eifionydd Jones (University Coll. of Swansea, Wales). p.131-6 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The individual secondary ionization coefficients in hydrogen are determined from measurements of the voltage collapse times and the theory of temporal growth of ionization currents in uniform electric fields ( $E$ ) at low pressures ( $p$ ). In hydrogen the secondary ionization processes are known to be cathode dependent. In order to examine the correlation between the values of the secondary coefficients and the work function of the cathode surface, the individual coefficients were determined and the actual work functions measured for a number of carefully treated cathode surfaces. It was found that, in the range of  $E/p$  investigated (50 to 200  $V \text{ cm}^{-1}$ ) ( $\text{mm Hg}$ ) $^{-1}$  the individual secondary coefficients representing ion ( $\gamma$ ) and photon ( $\delta/\alpha$ ) interaction with the cathode were in general increased by 100% ( $\gamma$  from 1.1 to  $3.8 \times 10^{-4}$  and  $\delta/\alpha$  from 6 to  $11 \times 10^{-4}$  at  $E/p = 80 \text{ V cm}^{-1}$  ( $\text{mm Hg}$ ) $^{-1}$  at  $20^\circ\text{C}$ ), when the work function of the cathode surface was reduced by only 0.25 ev. (auth)

## 17179

MEASUREMENT OF IONIZATION AND ATTACHMENT COEFFICIENTS IN AIR. J. Dutton, F. Llewellyn Jones, and R. W. Palmer (University Coll. of Swansea, Wales). p.137-41 of "Proceedings of the Fourth International Con-

ference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Precision measurements were made of the spatial growth of pre-breakdown ionization currents for cylinder air (free from  $\text{CO}_2$  and water vapor and passed through liquid air traps) for values of the parameter  $pd$  ( $p$  is the gas pressure and  $d$  the gap distance) up to 2020 mm Hg cm and of sparking potential up to 71 kev. The measurements show that the growth of ionization is well represented by the generalized Townsend equation modified to take account of the process of attachment. The values obtained from the primary coefficient  $\alpha$  are in general agreement with previous workers, whereas the values for  $\alpha$  are about half those obtained for dried room air in the only other previously published investigation of this kind. Measurements at pressures of about 400, 700, and 1000 mm Hg show that the secondary ionization is dependent only on the value of  $E/p$  ( $E$  is the electric field) and on the nature of the cathode surface; the behavior of air in this respect is thus markedly different from that of hydrogen in which a marked dependence of secondary ionization on pressure due to the destruction of excited molecules in collisions of the second kind has recently been observed. (auth)

17180

IONIZATION AND ATTACHMENT IN DRY AIR. A. N. Prasad and J. D. Craggs (The University, Liverpool). p.142-5 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

A simultaneous correlation of the data relating to ionization and attachment in dry air, obtained from high pressure swarm experiments and those from low pressure single collision conditions, is attempted. From such a correlation it is shown that the assumption of a Maxwellian electron energy distribution in the former type of experiments would yield a better reconciliation of all the existing experimental data than a Druyvesteyn distribution. (auth)

17181

SECONDARY IONIZATION IN HUMID AIR. J. M. Meek (The University, Liverpool). p.146-9 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Measurements of the secondary ionization coefficient  $\gamma$  in humid air show that the magnitude of  $\gamma$  declines rapidly with increasing partial pressure of water vapor, and that there is a roughly exponential relation between  $\gamma$  and  $p_{\text{w.d.}}$ , the product of water vapor pressure and gap length. This observation suggests that photoabsorption by water vapor may influence the value of  $\gamma$ . Other evidence shows that photoabsorption, possibly by oxygen, may also affect  $\gamma$  in dry air. (auth)

17182

EXPERIMENTAL TOWNSEND  $\alpha$  VALUES OF MOLECULAR GASES. A. E. D. Heylen (Queen Mary Coll., London). p.150-5 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Townsend ionization coefficient  $\alpha$  values were measured

over the range  $55 < E/p_0 < 110$  for n-butane, n-pentane, isopentane, and cyclopentane. It was found possible to follow the current growth due to ionization of the gas over a multiplication range exceeding seven orders of magnitude. The results agree well with previous breakdown measurements and the influence of molecular structure on  $\alpha$  and sparking potential  $V_s$  are briefly discussed. (auth)

17183

THEORETICAL DETERMINATIONS OF THE ELECTRON ENERGY DISTRIBUTIONS, DRIFT VELOCITY AND TOWNSEND  $\alpha$  COEFFICIENT FOR HYDROGEN. A. E. D. Heylen and T. J. Lewis (Queen Mary Coll., London). p.156-60 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The electron-energy distribution functions for hydrogen in a uniform electric field are determined over a wide range of  $E/p$  from fundamental cross section data. From these distributions and the elastic collision cross section it is possible to calculate the drift velocity and this has been done using two different elastic collision models, one of which is an exponentially decreasing function of the energy and the other is the Kihara form which decreases inversely with electron velocity. The resultant drift velocities are compared with experimental values up to  $E/p = 200 \text{ V cm}^{-1} (\text{mm Hg})^{-1}$ . From the distribution function and drift velocity the ionization  $\alpha$  coefficient is derived and compared with the experimental values given by Rose. The method shows the influence of the various collision cross sections clearly and the effect on the distribution function of the non-radiative  $^3\Sigma_u$  and  $^3\Sigma_g$  excitations is demonstrated. Inclusion of these as well as the usual optical ones yields a value of  $\alpha$  which is lower than the experimental one by a factor of 3. At low  $E/p$  vibrational and rotational excitations are shown to be more important than elastic processes and their inclusion causes the distribution function to approach the Maxwellian form. Consequently, the calculated values of  $\alpha$  are then in much better agreement with experiment below  $E/p = 50 \text{ V cm}^{-1} (\text{mm Hg})^{-1}$ . (auth)

17184

THE EFFECT OF GAS PURITY, TUBE GEOMETRY, AND METHOD OF CALCULATION ON THE IONIZATION COEFFICIENTS IN HYDROGEN AND IN THE INERT GASES. D. E. Davies, J. G. C. Milne, and J. Myatt (University Coll. of North Staffordshire, Keele, Eng.). p.161-3 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

A comprehensive study was made of the primary and secondary ionization coefficients in hydrogen and in the inert gases under uniform field conditions. Three types of tubes—a bulk electrode tube, simple tubes with electrodes of evaporated metallic films and film electrode tubes with guard rings—were used. For the range of  $E/p$  covered in hydrogen (50 to  $400 \text{ V cm}^{-1} (\text{mm Hg})^{-1}$ ) the values of  $\eta$  (the number of ionizations per volt) obtained were lower than those previously determined. Experiments show that the improved gas purity, better tube geometry and the electrode cleanliness (all of which are possible with the evaporated film tubes) contribute to the lower values of  $\eta$ . The importance of the correct calculation of  $\eta$ , by allowing both for secondary effects and for the variation of  $I_0$  (the initial photoelectron current from the cathode) due to the previous history of the cathode, will be

discussed. Preliminary values of  $\eta = f(E/p)$  in the inert gases are presented. (auth)

17185

MULTIPLICATION IN NON-UNIFORM FIELDS. R. N. Franklin (Clarendon Lab., Oxford). p.164-8 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The question of the applicability of Townsend's ionization coefficient  $\alpha$  to electron multiplication in non-uniform fields was studied. Arguments for the shape of the curve of current multiplication as a function of gas pressure, as discovered by Stoletow with a plane electrode system, hold in a modified form for any shape gap if  $\alpha$  is a function of the local field alone. A comparison is made of theory and experiment for maximum pressure and current multiplication. (M.C.G.)

17186

A UNIFIED THEORY OF BREAKDOWN AND THE GLOW DISCHARGE. A. L. Ward and M. J. Reddan (Diamond Ordnance Fuze Labs., Washington, D. C.). p.169-74 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Townsend's basic ionization equations for cold-cathode discharges between parallel plates are modified by Poisson's equation to account for the distortion of the field by space charges. Numerical calculations of voltage vs. current-density static characteristics have been made on the IBM 704 computer. The regions of validity of earlier breakdown approximations are indicated. The sub-normal, normal and abnormal glow regions are shown to develop as the current is progressively increased. Although comparison with experimental data is made difficult by the changing area of discharges, data both from this laboratory and from other laboratories indicate the validity of the calculations. (auth)

17187

BREAKDOWN BELOW THE PASCHEN MINIMUM. Heinz Niesters (Technische Hochschule, Aachen). p.175-80 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Voltage-current characteristics yielded breakdown potentials and breakdown currents for uniform electric fields in hydrogen between platinum electrodes,  $pd$  of 1.05 down to 0.54 Torr cm ( $p$  = pressure,  $d$  = electrode distance) and various intensities of external illumination. A new type of electrodes with special design for measurements below the Paschen curve minimum was developed and tested. The first Townsend ionization coefficient  $\alpha$  was measured and finally the root laws were proved, particularly in the region below the minimum. (auth)

17188

A. C. BREAKDOWN POTENTIALS. Laurenz Graf (Technische Hochschule, Aachen). p.181-4 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

A-c breakdown was treated experimentally in uniform fields. Breakdown potentials in hydrogen are discussed and compared with those in iodine over a frequency range

continuously up to  $2 \times 10^7$  cps. The frequency response of hydrogen breakdown is beginning with a gradually increasing amplitude of the breakdown field. By increasing the field the attenuated action of the positive ions is being compensated. Effects of trapped ions, however, decrease the breakdown voltage and cause a maximum at a certain frequency. This maximum does not occur with iodine owing to its low ionization energy and attaching behavior. (auth)

17189

THE INFLUENCE OF METASTABLE ATOMS ON THE STABILITY OF DISCHARGES. P. J. Hutton (Clarendon Lab., Oxford). p.185-8 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

It is shown that the Penning effect is not a secondary process capable of turning a (Townsend) discharge, maintained by electron emission from the cathode due to an external agency, into a self-sustaining discharge. In a Townsend discharge in a uniform field, in which the Penning effect operates, a central region is first considered in which the influence of the electrodes on the steady state distribution of metastables is negligible. The finite electron current multiplication between two equipotential planes in this region is then shown to be decreased by the insertion at these places of new electrodes, whether these be perfectly reflecting or perfectly 'absorbent' to incident metastable atoms. (auth)

17190

SOME ELECTRICAL CHARACTERISTICS OF THE PARALLEL-PLATE TOWNSEND DISCHARGE. R. S. Sigmund (Univ. of Norway, Trondheim). p.189-94 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Experimental and theoretical investigations were carried out on the parallel-plate discharge systems (i) oxidized Ni-electrodes in dry air, and (ii) pure Cu-electrodes in highly purified hydrogen, at  $pd$ -values ranging from 1 to 5 Torr-cm operated in the Townsend region. The principal results obtained so far are: (1) Static current-voltage characteristics. Using a simple R-C stabilizing network and no external cathode irradiation the U-I characteristics of the systems were found to be almost horizontal ( $U = U_s$ ) up to  $25 \mu A$  (i) and  $150 \mu A$  (ii), this being an order of magnitude more than the Townsend plateau lengths previously reported. A further increase in  $I$  is accompanied by oscillations resulting in a steeply falling U-I curve, which cannot be considered part of the true static U-I characteristic. (2) Discharge impedance. System (ii): At  $pd = 3.81$  Torr-cm,  $I = 10$  to  $120 \mu A$ , the complex impedance was measured using a small superposed a-c voltage (1 to 1000 kc/s), giving an equivalent circuit for the discharge comprising a negative resistance  $7-13 \text{ k}\Omega$  in series with an inductance  $(4.8 \times 10^{-6}/I)$  H, paralleled by the gap capacitance  $2.5 \text{ pF}$ . System (i): At  $pd = 1$  Torr-cm,  $I = 5$  to  $20 \mu A$ , stability measurements indicated a negative resistance  $70-100 \text{ k}\Omega$  and an inductance  $(1.2 \times 10^{-4}/I)$  H. (3) Theoretical evaluation of self-inductance of the Townsend discharge. Neglecting space charge effects, the self-inductance of (ii),  $pd = 3.81$ , was calculated from Davidson's approximate current growth formula and the available mobility and ionization coefficients data. The results agree well with the impedance

measurements. (4) The long plateaus and the good agreement between the experimental and the calculated self-inductance of the Townsend discharge indicate that space charge effects are unimportant up to far higher current densities than has hitherto been assumed. Measurements of the discharge inductance will in a simple way furnish information about the relative importance of the various secondary ionization processes, equivalent with that obtained from breakdown time lag measurements. The designing of a Townsend discharge voltage reference tube expected to have a stability and voltage range exceeding that of the common glow discharge tube is in progress in our laboratory. (auth)

## 17191

A SURVEY OF RADIATION PROCESSES IN GASES. G. L. Weissler (Univ. of Southern California, Los Angeles). p.195-201 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Interactions of vacuum uv photons with gases were studied with different techniques: spectroscopic term analysis, total absorption coefficients, determination of total photoionization cross sections, mass spectroscopic ion analysis leading to specific photoionization cross sections, and ion-molecule reactions. Representative results are discussed. (auth)

## 17192

THE IMPRISONMENT OF RESONANCE RADIATION. P. F. Little (Atomic Energy Research Establishment, Harwell, Berks, Eng.). p.202-5 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Early treatments of the movement of resonance radiation as diffusion in its own gas gave a quadratic dependence of the decay time on pressure, where experimentally a linear relation was found. Direct calculations of the transport rate have yielded the correct dependence, and one explanation of the failure of the first attempts was that no mean free path existed for photons of a broadened line in thermodynamic equilibrium. It is shown that a mean free path may be defined, and that a correct diffusion treatment gives the linear relation desired. The results are in good quantitative agreement with experiment. Other important physical processes are mentioned. (auth)

## 17193

SPECTROSCOPIC INVESTIGATIONS RELATING TO AUTOIONIZATION AND DIELECTRONIC RECOMBINATION. W. R. S. Garton, A. Pery, and K. Colding (Imperial Coll., London). p.206-9 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Autoionization effects in atomic spectra are discussed and illustrated by extremely diffuse double-electron transitions in the absorption spectra of alkaline-earth metal vapors. The effects of the presence of strongly autoionized levels in the inert gases Ar through Xe, on the photoionization continuum, on the quartz-ultraviolet dispersion and on the electron recombination coefficient are discussed. A rough estimate has previously been made of the recombination coefficient arising from  $\text{Ar}^+ + e \rightarrow \text{Ar}^{**} \rightarrow \text{Ar} + h\nu$  where  $\text{Ar}^{**}$  represents a doubly excited state of neutral

argon. Doubt is cast on this estimate, by the results of our recent measurements of the oscillator strengths of doubly-excited transitions in krypton; the values obtained are much lower than expected. This result is surprising, since it leaves the problem of accounting for the magnitude of the measured values of the refractive index of Kr. (auth)

## 17194

PHOTON PROCESSES IN THE BREAKDOWN MECHANISM. D. K. Davies, J. Dutton, and F. Llewellyn Jones (University Coll. of Swansea, Wales). p.210-14 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Results of accurate measurement of secondary ionization coefficients in uniform fields in hydrogen at high pressures ( $\approx 450$  mm Hg) are given and discussed. It is shown that at a given  $E/p$  the secondary ionization coefficient  $\omega/\alpha$  depends upon the state and nature of the material of the cathode surface and also upon the gas pressure. Discussion of these results shows that the dependence of  $\omega/\alpha$  on the gas pressure may be explained on the assumption that the secondary ionization process is predominantly due to photon action at the cathode and that destruction of excited molecules occurs in collisions of the second kind with neutral gas molecules. Theoretical computations show that values of the secondary coefficient calculated from fundamental atomic constants are in agreement with those observed experimentally. (auth)

## 17195

INTENSITY AND ABSORPTION COEFFICIENTS OF A GAS-IONIZING RADIATION EMITTED BY GAS-DISCHARGES IN  $\text{O}_2$  AND  $\text{N}_2-\text{O}_2$  MIXTURES. Alfred Przybylski (Universität, Hamburg). p.215-18 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Gas-ionizing radiation is investigated by excluding the surface photoelectric effect. The source of radiation is a corona discharge in a cylindrical discharge tube with a wire of 0.15 mm diameter. In  $\text{O}_2$  there is observed a component of radiation with  $\mu \approx 38 \text{ cm}^{-1}$  and an intensity of about  $10^{-3}$  photons per electron in the discharge. At pressures below 15 mm Hg two further components are reaching the ionization chamber with  $\mu \approx 250 \text{ cm}^{-1}$  and  $\mu \approx 550 \text{ cm}^{-1}$ . In  $\text{N}_2$  there is a radiation with  $\mu \approx 700 \text{ cm}^{-1}$  and an intensity of about  $3 \times 10^{-3}$  photons per electron. Investigations in  $\text{N}_2-\text{O}_2$  mixtures allow to describe the properties of gas-ionizing radiation in air. (auth)

## 17196

PHOTODETACHMENT CROSS SECTION FOR THE NEGATIVE ION OF ATOMIC OXYGEN. Stephen J. Smith (National Bureau of Standards, Washington, D. C.). p.219-24 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The spectral dependence of the cross section for the process,  $\text{O}^- + h\nu \rightarrow \text{O} + e$  was accurately measured in the range of photon wavelengths from 4000 Å to near the threshold at 8460 Å with approximately 300 Å resolution. A beam of low-energy, mass-selected negative atomic oxygen ions was illuminated in high vacuum with filtered radiation from a high intensity carbon arc lamp, and the current of free electrons produced by photodetachment was collected and measured. Measurements were made with

quasi-monochromatic light from each of thirteen narrow band filters relative to values obtained with a control filter at 5280 Å. Knowledge of photodetached electron current, ion current, and light intensity allows calculation of the relative cross section. A probable error of about 2% is attached to the relative values obtained for each filter. The cross section rises smoothly from threshold to a maximum at about 5800 Å, and appears to be nearly flat to wavelengths as short as 4000 Å. A calculation is used to extend the cross section to higher energies, including contributions from photodetachment leading to  $^1D$  and  $^1S$  states of atomic oxygen. The results of the experiment are compared with recent calculations of the  $O^-$  photodetachment cross section. (auth)

17197

CALCULATION OF THE  $1s-2p$  ELECTRON EXCITATION CROSS-SECTION OF ATOMIC HYDROGEN BY THE SCHWINGER VARIATIONAL METHOD. A. E. Kingston, B. L. Moiseiwitsch, and B. Skinner (Queen's Univ., Belfast). p.236-9 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The Schwinger variational method is employed to calculate the cross section for the  $1s-2p$  excitation of hydrogen atoms by electron impact, allowance being made for both distortion and polarization. Satisfactory agreement is found with the recent experimental data obtained by Fite and Brackmann. (auth)

17198

MEASUREMENT OF OPTICAL EXCITATION FUNCTIONS IN MERCURY AND HELIUM WITH EXCITATION BY MEANS OF ELECTRONS. H. M. Jongerius, C. Smit, and J. A. Smit. p.240-3 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In Dutch)

Measurements are described of relative optical excitation functions of several mercury and helium lines at low gas pressure (about  $1 \times 10^{-3}$  mm for Hg and  $2 \times 10^{-3}$  to  $2 \times 10^{-2}$  mm for He), and at a low electron beam current ( $\approx 25 \mu A$ ). Most excitation curves obtained show a complex structure with peaks just above threshold. For Hg, also, relative intensities have been measured of several visible and u.v. lines at an electron energy of 15.75 ev. For this energy the excitation cross section of the line 4047 Å proved to be  $1.3 \times 10^{-18} \text{ cm}^2$ . (auth)

17199

FORCES ON ION BOMBARDED SURFACES. Gottfried Wehner (General Mills, Inc., Minneapolis). p.245-9 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Forces on ion-bombarded metal electrodes which are immersed like large negative Langmuir probes in a low pressure plasma may arise from radiometer effects, rebounding neutralized ions and ejected sputtered atoms. Measurements of these forces were made with a quartz fiber torsion balance or a "radiometer-like" device mounted in a mercury plasma of low gas pressure (0.2 micron). Voltage is applied to the vanes through a wire which dips into a small bowl filled with liquid gallium or water-cooled mercury. The vanes are insulated at their backsides and kept above 300°C in order to prevent mer-

cury condensation. The bombarding ion current densities are  $2 \text{ mA/cm}^2$ . Results show that radiometer forces become negligibly small at gas pressures below 0.5 micron. With noble metals or metals from which surface layers have been removed by sputtering, the forces rise with ion energy in the same manner as do sputtering yields. The fact that the forces become negligibly small below the sputtering onset energy indicates that the accommodation coefficient for  $Hg^+$ -ions on clean metal surfaces must be very close to unity. The evaluation of the sputtering branch in the force curves shows that the average kinetic energy of sputtered atoms is unexpectedly high, i.e., of the order 10 to 20 ev. Results differ for oxide covered metals in that the bombarding ions are not fully accommodated. Here, the forces rise to a maximum at around 20 ev, then decrease with increasing ion energy (probably because ions which penetrate the surface are better accommodated) until sputtering sets in and the forces rise again. (auth)

17200

INFLUENCE OF THE ANGLE OF INCIDENCE ON SPUTTERING YIELDS. Gottfried Wehner (General Mills, Inc., Minneapolis). p.250-1 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Small metal spheres are bombarded by uniform  $Hg^+$ -ion beams of low energy (125 to 800 ev). Comparison of micrographs of the spheres before and after sputtering makes it possible to determine the influence of the angles of incidence on sputtering yields. Iron, Ta, and Mo showed a pronounced increase in yield at more oblique incidence of the ions while Au, Ag, and Pt showed this effect only slightly. (auth)

17201

SPUTTERING OF SINGLE CRYSTAL METALS BOMBARDED WITH RARE GAS IONS OF LOW ENERGY (50-350 ev). M. Koedam (Rijksuniversiteit, Utrecht). p.252-4 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Single crystals of Cu and Ni were bombarded with rare gas ions of low energy. The directional distribution of the atoms sputtered from a (111) and a (110) surface bombarded with normally incident ions has been determined. Certain preferential sputtering directions are found. The sputtering yield in the preferential (110) direction has been determined as a function of the ion energy (50 to 350 ev) for  $Kr^+$ ,  $Ar^+$ , and  $Ne^+$  ions. (auth)

17202

THE NON-LINEAR CHARACTER AS A FUNCTION OF INTENSITY OF CATHODIC SPUTTERING AT HIGH ENERGY AND ITS VARIATION WITH TEMPERATURE. C. Casignal and G. Ranc (Centre d'Etudes Nucléaires, Saclay, France). p.255-6 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In French)

A new cathode sputtering theory at high energy is presented which has been elaborated by taking in account the non-linearity of this phenomenon with the density of the impinging ions. This theory allows one to predict the influence of target temperature on the rate of cathode sputtering. This influence is experimentally demonstrated. (auth)

17203

SPUTTERING OF COPPER-MONOCRYSTALS BY BOMBARDMENT WITH 20 keV Ar<sup>+</sup>. P. K. Rol, J. M. Fluit, F. P. Viehböck, and M. de Jong (F.O.M. Laboratorium voor Massaspektrografie, Amsterdam and Universiteit, Amsterdam). p.257-9 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The sputtering yield of copper monocrystals is quite different from that of polycrystalline copper. The sputtering yield for oblique incidence is large in the directions, in which the crystal is untransparent, and small, in those in which the crystal is transparent. The angular distribution of the sputtered particles shows six maxima for a (111) crystal surface and four maxima for a (100) crystal surface. (auth)

17204

ANGULAR DISTRIBUTION OF SPUTTERED PARTICLES AND SPUTTERING RATE FOR HIGH SPEED IONS. Branka Cobić and Brana Perović (Boris Kidrich Inst. of Nuclear Sciences, Belgrade). p.260-2 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The influence of target temperature and ion bombardment time on the angular distribution of sputtered particles and on the sputtering rate for high speed ions was examined. Polycrystalline Cu and Pb targets were bombarded by Ar<sup>+</sup>, Kr<sup>+</sup>, and Xe<sup>+</sup> ions. The angular distribution of sputtered material was measured at three different temperatures (a) without target cooling, (b) with direct water cooling of the target, and (c) with direct liquid air cooling. It was found that by prolonged ion treatment of the target a pure cosine distribution could be obtained. Deviations were more pronounced when the mass number of the impinging ion was smaller. The sputtering rate was obtained by gravimetric analysis of the target before and after bombardment and by measuring the ion current. (auth)

17205

THE EFFECT OF THE PREVIOUS HISTORY OF THE CATHODE ON ITS WORK FUNCTION, ON ITS SPARKING POTENTIAL IN HYDROGEN, AND ON FORMATIVE TIME LAGS IN HYDROGEN. D. E. Davies, R. K. Fitch, B. J. Hopkins, and C. F. Gozna (University Coll. of North Staffordshire, Keele, Eng.). p.263-5 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The development of a simple parallel-plate tube with evaporated film electrodes has allowed the measurement of work function of a cathode, its sparking potential in hydrogen and formative time-lags in hydrogen to be made with the same gas sample and with the same cathode surface. Previous discharges ( $\approx 10^{-7}$  amp) appreciably altered the work function ( $\approx 0.3$  ev) and the sparking potential ( $\approx 30$  V) of a copper cathode in hydrogen. With nickel cathodes, covered with a coating of barium or strontium oxide, the effect was even greater. Experiment showed that the positive ions of the previous discharge accumulated on the cathode surface and set up a reverse potential which altered both the work function (of the copper film cathode) and its sparking potential. The effect of such charge accumulation on the formative time-lags in hydrogen will be

presented and discussed. The method allowed a linear relationship to be established between the work function of a cathode surface and the sparking potential of that surface in hydrogen. (auth)

17206

THE NORMAL CATHODE FALL ON SINGLE CRYSTAL CATHODES. G. J. M. Ahsmann and Z. van Gelder (N. V. Philips' Gloeilampenfabrieken, Eindhoven, Netherlands). p.266-70 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

A glow discharge was applied to a number of single crystal cathodes. For most crystals the burning voltage depends on the orientation of the crystal face. Some crystal faces such as the (100) face of germanium are not stable but become somewhat roughened by the discharge; it appears that there is a tendency for another crystal face to be exposed by sputtering, probably the (111) face. It is shown that it is possible to obtain very reliable and stable values of the normal cathode fall by using single crystal cathodes. (auth)

17207

A GENERALIZED THEORY OF THE POSITIVE COLUMN IN MERCURY RARE-GAS DISCHARGES. M. A. Cayless (British Thomson-Houston Co., Ltd., Rugby, Eng.). p.271-5 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Schottky's theory of the positive column is generalized to include ionization from previously excited states, using the actual cross section curves for excitation and ionization, the Ramsauer collision cross section curves of the rare gases, and taking into account the imprisonment of the resonance radiation. The theory is applicable to tubes of any cross-sectional shape, the equations being solved by numerical methods, using a digital computer. The distributions of the excited atom and ion populations are evaluated for several discharges in circular tubes. It is shown that in tubes of elliptical cross section the plasma becomes increasingly constricted to the central part of the tube as the eccentricity is increased, especially when two-stage ionization is predominant. A much more even distribution of the plasma can be produced in flat tubes of other more suitable shapes, with higher electron temperatures and more resonance-radiation output than comparable circular tubes. (auth)

17208

INVESTIGATION OF LOW-FREQUENCY OSCILLATIONS IN LOW PRESSURE DISCHARGES. B. Saggau (Technische Hochschule, Stuttgart). p.280-2 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In German)

Low-frequency oscillations are observed in cylindrical discharge tubes with a neon filling of 2 mm Hg pressure. The observed frequency is the same whether the discharge is operated with a cold cathode or hot cathode. It is found that the frequency neither depends on the cathode fall nor on the positive anode fall. The frequency dependence on the interelectrode distance is given for both cases. With a movable double probe the field distribution is determined at five consecutive times during one oscillation. The excess space charge distribution resulting is presented (cf. graphical differentiation). (auth)

## 17209

A CONTRIBUTION TO THE INVESTIGATION OF THE STRIATED POSITIVE COLUMN. M. Klerk (Philips Research Labs., Eindhoven, Netherlands). p.283-5 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

An experimental investigation of the striated column of low pressure d-c discharges and h.f. discharges in the range of 10 to 30 Mc/sec led to the conclusion that the origin of the striations is principally seated in the plasma of the column itself. In some cases, however, the boundary conditions at the ends of the column cause a disturbance of the plasma and so give rise to the occurrence of striations. (auth)

## 17210

SPECTRAL INVESTIGATIONS OF THE MOVING STRIATIONS IN A NEON GLOW DISCHARGE. Alfred Rutsch (Universität, Greifswald, Ger.). p.286-92 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In German)

The distribution of the intensity of several visible spectral lines, as well as of ultraviolet radiation and concentration of metastable atoms along moving striations (slow type) of a glow discharge in neon is determined. Some results of simultaneous performed probe measurements are also communicated. (auth)

## 17211

NOISE IN GAS DISCHARGES. A. R. Galbraith and A. van der Ziel (Univ. of Minnesota, Minneapolis). p.297-300 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The noise in the frequency range 0.5 to 30 Mc/s flowing to a current-carrying probe immersed in a cold-cathode gas discharge tube comes from three sources: a low-frequency noise mechanism located near the cathode; a high-frequency noise mechanism in the positive column located in the plasma sheath at the wall; and a shot noise mechanism showing full shot noise of the electron and the ion current arriving at the probe. By shielding, the latter source can be made to predominate below 5 Mc/s. (auth)

## 17212

RESEARCH ON THE MECHANISM AT THE CATHODE OF A GLOW DISCHARGE. E. Badarau and I. Popescu (Institutul de Fizica, Academia R.P.R., Bucharest). p.301-5 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In German)

The role of the cathode fall space and glow in maintaining the discharge is often interpreted by means of dubious assumptions which lead to disagreement of experiment and theory. The results are presented of work on this problem. The main difficulties involved were errors in relatively short-time determination and interpretation in the region of ion motion in specific gases and in interpretation of the localization of ionization and of the charge carriers in the dark space and negative glow. (T.R.H.)

## 17213

NEW METHOD OF MEASUREMENT OF RELAXATION-TIMES IN GLOW DISCHARGE PLASMA. L. Pekárek

(Inst. of Physics, Czechoslovak Academy of Sciences, Prague). p.306-8 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The direct measurement of relaxation times in living d-c plasma, such as is the time which characterizes the velocity of the reestablishment of equilibrium after a small local perturbation, meets with serious difficulties. The small local perturbation of glow discharge plasma can be easily realized, e.g., by means of a voltage pulse of short duration, which is applied to a ring-shaped external electrode. But the locus of maximum perturbation not only decays in time, but also shifts with a translational movement. Thus, the time-dependence of any parameter of a disturbed plasma, measured directly at a single point which does not move with the locus of maximum disturbance, will be essentially distorted by the translational movement of the disturbance. In order to measure relaxation time, which characterizes the rate of reestablishment of space-charge equilibrium in the plasma after a local perturbation, we used a method, based on the phenomenon of the wave of stratification, described earlier. This method though using a stationary photomultiplier enables us to eliminate the distortion caused by the translational velocity: microscopic parameters of the wave of stratification (velocity of propagation, translational velocity, spatial period), are measured, and an evaluation method based on the theory of the phenomenon is used to obtain the value of the relaxation times. The measured relaxation time of a space charge is in many cases compatible with the diffusion lifetime of positive ions. In other cases, the relaxation time is considerably longer than the lifetime of positive ions. Slower processes, such as the diffusion and decay of metastable atoms, etc., must be taken into account to explain this result. In some cases, two or even three relaxation times can be found simultaneously, each of them corresponding to a different process of decay of the space-charge disturbance. (auth)

## 17214

THE IMPEDANCE AND RECOVERY TIME OF GLOW DISCHARGES IN MIXTURES OF RARE GASES. G. J. M. Ahsmann (N. V. Philips' Gloeilampenfabrieken, Eindhoven, Netherlands). p.309-13 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

It is shown that the complex impedance of a glow discharge in a rare gas is considerably reduced by the addition of another rare gas with a lower ionization potential than the main gas. Both the real and the imaginary part decrease. It is shown that the self-inductance of the discharge decreases inversely proportionally to the mobility of the ions in the Crookes dark space. The addition of a rare gas with a lower ionization potential than the main gas also has a large effect on the recovery time of the discharge. (auth)

## 17215

CORONA DISCHARGES IN EXPLOSIVE GAS/AIR MIXTURES. D. Müller-Hillebrand (Inst. of High Tension Research, Uppsala). p.325-9 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Measurement arrangement: between two plane electrodes of 4.2 m diameter in 0.55 to 1.5 m distance was a point electrode with 1.0 to 25 mm diameter established on the earthed side. The current was measured at the electrode in air or in a 20 liter container with an explosive hydrogen or propane mixture. At negative point in air were Trichel-pulses with a charge of ca.  $0.1 \times 10^{-9}$  Coul at the 1 mm point and  $1.3 \times 10^{-9}$  Coul at the 10 mm point measured and at positive 1 mm point pulses of burst corona, at the 10 mm point pre-onset streamer with a charge of about  $10 \times 10^{-9}$  Coul and  $8.4$  to  $19.2 \times 10^{-9}$  ions per cm streamer length. In hydrogen/air mixture no streamers could be detected at positive point, on the other hand there were streamers in propane/air mixture. The ignition current at 1 mm positive and negative point is almost as big as the strength of the breakdown current and essentially lower at the 10 and 25 mm point. The ignition of propane at 1 and 10 mm point does not take place through one single streamer, at 25 mm point it is not quite conceivable that a single spark from the point to the container's aluminum foil caused the ignition. The ignition of the hydrogen-air mixture without streamer seems to start at the anode. The practical result is: a corona-discharge from a 1 mm point does not ignite an hydrocarbon/air mixture at currents up to  $150 \mu\text{A}$  and can neutralize static electrification of petrol in a tank with  $150 \mu\text{Coul/s}$  effectivity. (auth)

17216

THE TIME RESPONSE OF THE CORONA DISCHARGE IN SHOCK WAVES. W. Fucks and H. Grönig (Technische Hochschule, Aachen). p.330-2 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The time response of a positive d-c corona discharge between two spheres was investigated under the influence of fast density variations in a shock tube. By properly adjusting the geometrical dimensions of the shock tube and the corona probe, the density and velocity dependence of the corona discharge can be separated. The measurements show that the corona probe, employed in a shock tube, is sensitive to density variations up to frequencies of about 50 kc/s due to its spatial resolution. (auth)

17217

AN INVESTIGATION OF D. C. CORONA-DISCHARGES USING MICROWAVES. J. S. T. Looms (Central Electricity Research Labs., Leatherhead, Eng.). p.333-5 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The properties of d-c corona discharges in air as media for microwave propagation and as sources of radio-noise were investigated for wavelengths about 3 cm. It is concluded that the electron-density is small and that interference by corona on power-lines with microwave communications is unlikely to be serious. No such emissions as occur from dimple-arcs were found from cathode spots in corona discharges either in air or in nitrogen. (auth)

17218

PROGRESS IN ARC RESEARCH. Walter Lochte-Holtgreven (Universität, Kiel). p.337-42 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Investigations concerning the formation of negative ions

are reported. Heavy negative molecular ions were observed by M. v. Ardenne. Quantitative studies of negative atomic ions were carried through by Branscomb and Boldt. Positive and negative ions were found by flash photolysis (Norrish, Porter e.a.). Free radicals were collected and investigated by Broida. The separation tube of Clusius was replaced by an arc device. Isotope separation and changes in the composition of an arc's plasma are discussed. The plasma of a high current arc may show local and time dependent variations of density in connection with jets from one of the electrodes. Consequences of this are touched upon. (auth)

17219

THE MOTION OF AN ARC IN A MAGNETIC FIELD. A. E. Robson (Atomic Energy Research Establishment, Harwell, Berks, Eng.). p.346-9 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The motion of an arc in a uniform magnetic field was investigated when the magnetic field was inclined to the plane of the cathode. In addition to the retrograde motion which occurs at low pressure, the track of the cathode spot has a drift component towards the acute angle between the field and the cathode. This drift is explained on the basis of the theory of retrograde motion proposed by Robson and von Engel. (auth)

17220

THE INFLUENCE OF CATHODE SURFACE CONDITIONS ON ARC MOVEMENT. P. E. Secker (Univ. of London). p.350-4 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Tests are described which demonstrate that the rate of movement of an arc in a transverse magnetic field is dependent on the degree of oxidation of the cathode surface. A qualitative explanation based on enhanced electron emission from the cathode due to positive ions deposited on the cathode surface is given. Photographic and other evidence supports the hypothesis that in a high current arc, multiple electron emission sites are set up on the cathode, each moving independently at a speed controlled by the cathode emission properties. (auth)

17221

THE CURRENT CONTINUITY AT THE ARC CATHODE. G. Ecker and K. G. Müller (Universität, Bonn). p.355-8 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The mechanism of the current transport at the arc cathode is discussed for the different cathode types. In the explanation of the field arc the emission according to Nordheim-Fowler proves to be too small compared to the measured extreme current densities of  $10^6 \text{ A/cm}^2$ . Considering the influence of the individual field component the mechanism of a field arc can be explained without further assumptions. (auth)

17222

NEW MODES IN LOW PRESSURE CATHODE OPERATION. Hans von Bertele (Technische Hochschule, Vienna). p.359-63 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August

1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

An experimental arrangement is described permitting independent temperature stabilization of emission zone and of the adjacent atmosphere for low pressure mercury arcs with cold metal cathodes. Specific operation ranges have been located having different emission modes, partly of hitherto not yet observed performance. Besides transitorial modes from the known spots and lines, two new modes with uniform, surprisingly low current densities (order 10 a/cm<sup>2</sup>) were detected operating at vapor equilibrium, i.e., without cathode material evaporation. Existence of one or perhaps two very efficient emission mechanisms of unknown nature is concluded. In the conventional cathode spot arcs several emission modes seem to operate in parallel, yet participating at different degrees, depending on the actual temperature conditions in and above the emission zone. (auth)

#### 17223

SOME PROPERTIES OF THE MERCURY VAPOUR ARC AT VERY LOW PRESSURES. Max Hoyaux and Paul Gans (Ateliers de Constructions Electriques de Charleroi, Belgium). p.364-9 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Laws for the moderate current and moderate pressure mercury vapor arc were established on the assumption that the mean free path is very inferior to the tube radius. However, post-calculation of the mean free path as a function of the experimental parameters shows that, in some instances, values as high as 5.5 times the tube radius are found. The effect of such a large mean free path upon the form taken by the equations of similitude is studied on the basis of a theory of Tonks and Langmuir. It is found that the equations of similitude remain formally the same as in the previous case. (auth)

#### 17224

SPECTROSCOPIC STUDY OF CARBON ARC BURNING IN INERT GASES. N. N. Sobolev, V. N. Kolesnikov, and V. F. Kitaeva (Physical Inst., Academy of Sciences, Moscow). p.370-3 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Numerous investigations show that the concept of thermal equilibrium is applicable to the low-current air arc at the normal pressure. This conclusion was often arbitrarily extended to the low-current arc discharge in inert gases. The paper deals with an experimental investigation of this problem. Carbon arcs in He and Ar at currents from 3 to 10 a at atmospheric pressure are investigated. The absolute intensities of H, He, and Ne lines and relative intensities of the Ba I, Ba II, Li I, and Cu I lines introduced into the arc were measured. The profiles of the H<sub>β</sub> line of the arc in He at 6 a were studied. It is established that: 1) Alongside the high-potential excitation lines of H, He, and Ar the near-axis sections in He and Ar radiate C<sub>2</sub> and CN bands. 2) Absolute populations of H, He, and Ne levels correspond to temperature T<sub>e</sub> ≈ 10,000 to 11,000°K. Relative populations of the same levels correspond to T<sub>e</sub> ≈ 3000 to 4000°. Temperature measured from CN band also equals T<sub>e</sub> ≈ 3000°. 3) The half-width of H<sub>β</sub> in He arc equals 0.5-1A. The profile of H<sub>β</sub> in He arc is described by the Holtsmark theory. The concentration of charged parti-

cles determined from the profiles of H<sub>β</sub> equals 1 - 5 × 10<sup>14</sup> cm<sup>-3</sup>, the degree of ionization 10<sup>-4</sup>. The latter may be ensured by H at T<sub>e</sub> = 8000°. The mobility of electrons in He arc is determined by scattering on H atoms. Discrepancy between T<sub>e</sub>, T<sub>r</sub>, and T<sub>i</sub> shows that the processes in He and Ar arcs are non-thermal. 4) Introduction of metals into He and Ar arcs perceptibly shifts the state of plasma toward equilibrium. At large concentration of Ba, Li, and Cu in He and Ar arcs the radiation of Ba II and Cu I at T<sub>r</sub> = 6000 to 7000° is the most intense on the axis of the arc. The peripheric region accounts for the maximal radiation of Ba I and Li I at T<sub>r</sub> = 3000 to 4000°K. The radiation of H, He, and Ar lines vanishes. Yet complete equilibrium is not attained. 5) To know the conditions under which it is possible to regard the arc plasma in inert gases as thermic, experiments at higher currents and pressures are needed. (auth)

#### 17225

TEMPERATURES IN THE HYDROGEN ARC PLASMA. W. A. Gambling (Univ. of Southampton, Eng.). p.374-7 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Arc plasmas at atmospheric pressure and above are normally assumed to be in a state of quasi-thermal equilibrium in which the difference between the electron and gas temperatures is small. However, recent work shows that the hydrogen arc plasma, at least at low currents, is not in thermal equilibrium and the electron temperature is appreciably above that of the gas. However, a consistent excitation (gas) temperature is still obtained except for currents near the transition current where, it has been suggested, electron excitation becomes appreciable leading to a non-thermal distribution of excited states. In order to test this hypothesis a mechanical switch was designed to enable discharges to be short-circuited very rapidly (in times <1 microsecond) and the decay of radiation was observed over a range of currents and pressures using a spectrograph and photomultiplier technique. Instead of a sharp drop in intensity which would be indicative of electron excitation, an initial rise was observed when the current was interrupted, similar to that obtained with hydrogen sparks, followed by a more gradual decay. This may confirm the high value of electron temperature in the steady-state plasma and this possibility is discussed in terms of the fundamental processes operative. (auth)

#### 17226

THE PROPERTIES OF NITROGEN UP TO 15,000°K. H. Maecker (Siemens-Schuckertwerke A. G., Erlangen, Ger.). p.378-80 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

With a newly developed cylindrical cascade arc for high power input, and with the development of the theory of the arc, it was possible to determine the electrical conductivity, the heat conductivity and the heat conduction function of nitrogen up to 15,000°K by means of electrical and spectroscopic measurements. (auth)

#### 17227

THE DECAY OF ARC TEMPERATURE BY THERMAL CONDUCTION. D. Whittaker (Univ. of Liverpool). p.381-4 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August

1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The cooling of a cylindrically symmetric positive column of an arc discharge after current interruption is theoretically analyzed assuming that the temperature decay is produced only by thermal conduction and the consequent contraction of the gas. The non-linear energy equation is given in a form suitable for solution when the gas density, thermal conductivity, and enthalpy are known functions of temperature. Results are given for the radial temperature decay of an arc in nitrogen. (auth)

17228

THE SUDDEN CHANGE OF A XENON HIGH-PRESSURE ARC IN AN ARC WITHOUT A FOCUSING SPOT AND ITS CATHODE MECHANISM. G. List and G. Pardemann (Physikalisch-Technisches Institut, Deutsche Akademie der Wissenschaften, Berlin). p.385-7 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In German)

After the sudden switch down of current intensity of an arc without focused spot from 10 to 2 a, the temperature of the cathode-surface and the current density before the cathode are observed up to the appearance of the focused spot. It shows that the thermionic emission of the cooling off cathode is sufficient to produce 80% of the necessary current if the simultaneous increase of voltage is added to the cathode fall. (auth)

17229

POST-ZERO PHENOMENA IN HIGH-CURRENT ARCS. V. K. Bisht, G. A. W. Rutgers, and D. Th. J. ter Horst (KEMA Labs., Arnhem, Netherlands). p.388-92 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Arc current and voltage around current zero were studied in two models of air-blast circuit breakers. If a large pressure gradient was made in the arc chamber by means of a throat, post-zero current was found only at very high natural frequencies ( $\approx 100$  kc/s, zero pause about 1 sec). At a smaller pressure gradient (model without throat), post-zero currents up to 6 a were measured, both in a 500 c/s circuit at 200 a r.m.s. and in a 50 c/s circuit at 2,000 a r.m.s. The arc reignited after voltage break-down if no measurable post-zero current existed; when post-zero current was recorded, reignition was caused generally by thermal break-down. (auth)

17230

SOME EXPERIMENTS ON DECAYING ARCS. H. Edels (The University, Liverpool). p.393-6 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Some properties of an arc after sudden interruption were measured. Measurements of the recovery of reignition voltage, total arc resistance, positive column resistance, total power loss, and gas temperature after the interruption of a d-c carbon arc in air and other gases are described. The arc burned horizontally and freely between 4 mm diam. carbon electrodes 2 to 10 mm apart and at currents from 10 to 50 amps. The results show that the recovery is predominantly controlled by thermal factors. (auth)

17231

ON THE REIGNITION OF A. C. ARCS. Werner Rieder and

Helmut Schneider (Inst. of Tech., Vienna). p.397-401 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The mechanisms of gap recovery and reignition of a-c arcs are considered under different conditions. There appears an unexpected step in the recovery curve in short gaps between clean electrodes at post-arc temperatures below about  $3000^{\circ}$ . As a result a shorter gap is able to withstand about twice the voltage than a longer one. This effect is believed to be due to the sweeping out the remaining electrons by the recovery voltage. At higher temperatures (after higher arc currents) and/or with contaminated electrodes emitting field or thermionic electrons, the electrons are replaced, and the recovery step does not appear. Under these conditions the post-arc current lasts longer and delays gap recovery or causes even a breakdown due to its Joulean heat. (auth)

17232

TIME-RESOLVED PHOTOGRAPHY OF ARRESTED DISCHARGES IN LONG GAPS. R. T. Waters and R. E. Jones (Associated Electrical Industries, Ltd., Aldermaston, Berks, Eng.). p.408-12 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Rotating cameras were used to record undamped rod-gap discharges suppressed at a late stage. Three new features of spark structure are shown: (1) Both positive and negative leaders are always stepped or beaded. (2) When well-developed both leader paths are simultaneously traversed by a continuous track moving from tip to electrode. Such return tracks also occur at suppression of the spark. (3) The inter-leader space is bridged by a glow discharge when the return strokes occur. The spark leader is compared with the lightning stepper leader and in some respects found analogous. (auth)

17233

SPACE CHARGE PHENOMENA IN IMPULSE SPARKOVER. R. T. Waters and R. E. Jones (Associated Electrical Industries, Ltd., Aldermaston, Berks, Eng.). p.413-17 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Rod-gap time lag behavior under long wavetail impulses was studied. Both short ( $\approx 20$   $\mu$ sec) and long ( $\geq 100$   $\mu$ sec) lags are observed, with a dead-time between the two groups. A superimposed-impulse technique shows the dead-time to be a period of increased breakdown strength in the gap. Time-resolved photography reveals no visible discharge growth during this time. The space charge created in the gap by the initial corona burst is found to seriously modify the prevailing field. It is concluded that long formative times are caused by a self-quenching action, which plays an important part in determining breakdown levels in impulse sparkover. (auth)

17234

THE INFLUENCE OF NUCLEI PRODUCED BY SPARKS ON THE BREAKDOWN VOLTAGE OF UNIFORM FIELD GAPS IN AIR. E. Kuffel (Metropolitan-Vickers Electrical Co., Ltd., Manchester, Eng.). p.418-23 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The initial stabilization of the breakdown voltage was studied for uniform field gaps in an enclosed air filled chamber. The experiments were carried out in filtered air, in unfiltered air of various humidities and in dry air. It is shown that the stabilization involves the conditioning of the electrodes and a gas conditioning effect. The number of sparks required for stabilization varied between 10 and 20 and depended on the humidity of the sample. In filtered air the initial breakdown voltages were always lower than the final stable values (approximately 1% lower) whereas in unfiltered air the first breakdown usually occurred at a higher voltage. The stable values for a given air condition remained within  $\pm 0.05\%$ . The formation of very small condensation nuclei (radius  $\approx 5 \times 10^{-7}$  cm) by the spark discharges was observed in filtered air. The rate of formation of these nuclei followed the same trend as the initial increase in the breakdown voltages. It is suggested that the presence of the nuclei affects the breakdown voltage slightly because of a process of electron capture. The stable breakdown values were reached when the nuclei concentration reached an equilibrium condition. (auth)

### 17235

LIGHTNING DISCHARGES AS ORIGIN OF WHISTLERS. Harald Norinder and Edgar Knudsen (Inst. of High Tension Research, Uppsala). p.424-30 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

A station for analysis of relations between lightning discharges and whistlers was operated near Uppsala. A definite program was realized during the thunderstorm season of 1958. It was found that whistlers occur in groups—whistler situations—with periods often of  $1\frac{1}{2}$  to  $2\frac{1}{2}$  hours, exceptionally of 5 to 6 hours. Whistlers sometimes occurred in great numbers for shorter periods of time between total cessations. These extended over hours, days, and even weeks. Whistler situations on days with thunderstorms were located by a CRO direction finder. It was found that while a thunderstorm in one direction produced whistlers, a simultaneous thunderstorm in another direction at about the same distance did sometimes not. Variations in the same thunderstorm of the electric field force from atmospherics related or not to whistlers resulted in that atmospherics with the highest field force were always followed by whistlers. This was explained partially by facilitated propagation for wave-packets in the low-frequency band around 5 kc/s and partially by high initial energy in the discharges causing whistlers. A comparison in the same thunderstorm of wave-forms from atmospherics not producing whistlers showed typically irregular variational forms and one single discharge in the lightning path. Wave-forms of whistler-producing atmospherics showed regular variational forms with frequencies around 5 kc/s. The wave-forms indicated in several cases multiple discharges in the lightning path. The wave-forms also allowed of an interesting explanation of the occurrence of unusual types of whistlers. (auth)

### 17236

FURTHER INVESTIGATIONS ON HASH IN FLUORESCENT LAMPS. Max Hoyaux and Paul Gans (Ateliers de Constructions Electriques de Charleroi, Belgium). p.502-6 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Both experimental and theoretical investigations were

performed on the hash in fluorescent lamps. The theoretical developments are based on a theory of small perturbations of a plasma about a stable state previously developed in our laboratory. The experimental investigations make use of special devices—the "plasmograph" and the "synchronized plasmograph"—which have been previously described in the literature. As a result of these investigations, the physical mechanism of the hash was completely explained and the experimental documents are in good agreement with the theory. (auth)

### 17237

RADIATION FROM A PULSE DISCHARGE. G. Porter and E. R. Wooding (The University, Sheffield, Eng.). p.515-17 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The duration and intensity of the radiation accompanying a current pulse through argon were measured and the influence of the initial gas pressure was studied. (auth)

### 17238

OPTICAL AND ELECTRICAL CHARACTERISTICS OF A HIGH-BRIGHTNESS FLASH-DISCHARGE OF SHORT DURATION. W. R. S. Garton, I. W. Celnick, H. Hessberg, and J. E. G. Wheaton (Imperial Coll., London). p.518-22 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

By exploiting recent advances in the design of high voltage capacitors, it was possible to construct improved flash-discharge tubes for the production of a strong continuous emission spectrum ("Lyman Continuum"), useful for the measurement of reversal temperatures of dense plasmas. Some first results of basic studies of current, light output and spectral composition, with fairly high time resolution, are described and illustrated. (auth)

### 17239

CROSS-SECTION MEASUREMENTS WITH CROSSED BEAMS. R. L. F. Boyd and A. Bokserberg (University Coll., London). p.529-32 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Measurements of collision cross sections of unstable substances, such as the atomic allotropes of molecular gases, require a method which avoids the effects of the containing chamber, electrodes and ambient gas. The method of modulated crossed beams is particularly appropriate because of the low beam pressure and delimited reaction volume. Some recent measurements of the ionization cross section of atomic hydrogen, using a discharge type atom source and obtaining mass analysis of the product ions by a trochoidal mass spectrometer having a 100% collection efficiency, are reported. (auth)

### 17240

ON THE HARMONICS RADIATING FROM MICROWAVE DISCHARGE IN AIR. Kinjiro Inada, Michizo Uenohara, and Takaya Masutani (Nihon Univ., Tokyo). p.768-73 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

It was found that the microwave discharge occurring in a low-Q cavity generates electromagnetic waves, the fre-

quencies of which are integral multiples of the input frequency, with fairly strong power. The relation between input and output power and the effect of gap-length and pressure, in such a discharge are considered. The experimental results show the linear relation of input-output characteristics, and the existence of optimum gap-length and gas pressure for each harmonic. It is proposed that this phenomenon can be used as a high power microwave frequency multiplier. (auth)

17241

COMPRESSION OF RADIATION FIELDS BY A MAGNETICALLY DRIVEN PLASMA SHELL. J. G. Linhart and

L. Th. M. Ornstein (European Organization for Nuclear Research, Geneva). p.774-7 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

A decrease in the volume of a cavity oscillating in one of its resonant modes results in the increase of its resonant frequency. If such a change of volume is sufficiently rapid the electromagnetic field of that mode is compressed adiabatically and its stored energy increases proportionally to the increasing resonant frequency. A brief theory of this mechanism for various types of resonators is given. An experimental arrangement is described, consisting of a cylindrical cavity at whose circumference a cylindrical shell-discharge is struck, resembling a hollow linear pinch. The heavy current passing axially through this shell causes it to contract and compress a radiation-field existing inside the cavity. Measurements on the movement of this cylindrical shell and its interaction with the modes of oscillation are presented. (auth)

17242

PLASMA WAVE-GUIDES AND RESONATORS FOR CM-WAVES. J. G. Linhart (European Organization for Nuclear Research, Geneva) and W. Zych (Inst. for Nuclear Research, Warsaw). p.778-85 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Propagation of electromagnetic waves in cylindrical columns of plasma is investigated. A brief summary of the corresponding theory is given including interpretation of dispersion relationships. The experimental arrangement is designed with the view of providing a plasma column which is magnetically confined and clearly separated from material walls. In this way it is possible to dissociate a guiding effect of walls from that of the plasma column. This is achieved by a reflex-discharge in a cylindrical cavity. The ratio of the radius of the cavity to that of the plasma column was in all experiments larger than 10. The plasma column forms thus a resonant structure, bound by the walls of the cavity. Three types of resonant modes were identified. The first is the cavity-mode, which is slightly detuned by the presence of the plasma column. The second is a coaxial mode, the plasma column playing the role of the inner conductor of a coaxial cavity. The third type of mode detected is the pure plasma mode, in which the field is concentrated within the plasma. A comparison between experiment and theory is attempted. (auth)

17243

THE VELOCITY AND DAMPING OF ALFVÉN WAVES IN A GAS DISCHARGE. R. A. Hardcastle and D. F. Jephcott (Atomic Energy Research Establishment, Harwell, Berks, Eng.). p.786-9 of "Proceedings of the Fourth International

Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The excitation of magnetic field oscillations in a toroidal gas discharge is described, and details of measurements of the phase velocity of propagation and the damping of the waves are given. The results are consistent with the assumption that the oscillations observed were Alfvén waves damped by collisions between ions and neutral gas atoms, and by resistivity effects. (auth)

17244

STUDIES OF THE LOW PRESSURE ARGON ARC IN A MAGNETIC FIELD. M. McChesney, P. C. McNeill, and J. J. Matthews (British Thomson-Houston Co., Ltd., Rugby, Eng.). p.871-5 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The behavior of an argon arc is examined in the pressure range 0.5 to 10 microns and in the presence of an axial magnetic field of up to 10 kilogauss. The arc carries currents of from 2 to 40 ka and takes place in a glass tube 10 cm diameter and 80 cm long. In addition to conventional voltage and current measurements, the behavior of the arc is examined with a Kerr cell camera, a rotating mirror camera and plate spectroscopy in the range 2000 to 6000 Å. Discharge spectra are observed midway between the electrodes; no AI radiation is observed, the spectra being predominantly due to AlI and AlIII with some evidence for AlIV. There is relatively little strong impurity radiation. The production of such spectra is considered for two types of equilibrium and yield similar values of electron temperature to those obtained from the discharge conductivity measured after current maximum. Lack of accurate cross section data prevents an alternative approach. The transverse velocity of the discharge column determined from the rotating mirror camera records is examined as a function of gas pressure, current and magnetic field strength. In the absence of magnetic field the velocity is found to be proportional to the average ion velocity as deduced from the Bennett relation; with applied magnetic field it is believed that electromotive forces influence the velocity. (auth)

17245

NON-EQUILIBRIUM ELECTRICAL AND RADIATIVE PROPERTIES OF HIGH TEMPERATURE AIR, NITROGEN, AND OXYGEN. P. Hammerling, J. D. Teare, and B. Kivel (Avco-Everett Research Lab., Everett, Mass.). p.1092-7 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

A theory for calculation of the radiation and electron density behind strong normal shocks is outlined. Non-equilibrium effects are specifically included by rate equations for the chemical, ionizing and radiative processes. Since many of the rate constants and excitation mechanisms are not known such a calculation must be regarded as qualitative. These unknowns can gradually be eliminated when the calculations are used in conjunction with an experimental program which explores regions sensitive to particular reactions. (auth)

17246

AN APPARATUS FOR THE PRODUCTION OF INTENSE SHOCK WAVES. J. K. Wright (Atomic Weapons Research

Establishment, Essex, Eng.). p.1105-9 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

A simple inexpensive apparatus is described for the production of two oppositely facing intense shock waves. Temperatures of the order of  $10^6$ °K are attained in 1 mm of deuterium when the two shocks collide. The use of such an apparatus in the study of shock structure and in measurement of the rate of attainment of equilibrium intensity of spectral lines is discussed. (auth)

17247

TRANSIENT HIGH TEMPERATURE GAS LAYERS IN DETONATION. C. H. Johansson and H. L. Selberg (Nitroglycerin Aktiebolaget, Vinterviken, Stockholm). p.1114-17 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The shock wave in gas-filled tubes obtained by detonation of high explosives was investigated by means of streak cameras and Kerrcell photos. For low pressures the front velocities observed appear essentially higher than theoretically expected. When the mean free path is of the same size as the dimensions of the tube a probable explanation is obtained by assuming that the front of the detonation products consists of particles or heavy molecules from which the gas molecules are reflected by a practically elastic impact. This leads to a front velocity equal to the double of the front velocity of the detonation products. For pressures between 760 and 4 mm Hg tests in glass and plexiglass tubes confirmed the result of Hikita and Yoneda that the inverted velocity of the shockfront increases linearly with the distance from the charge. This seems to indicate that the driving detonation products, act like a projectile of constant mass in conformity with Cook's conception of a detonation head. (auth)

17248

MICROWAVE STUDIES OF THE PROPERTIES OF IONIZED AIR IN A SHOCK TUBE. D. L. Schultz (National Physical Lab., Teddington, Middx, Eng.). p.1118-27 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The results are given of microwave absorption measurements in argon and air partially ionized at temperatures up to 5000°K by strong shock waves. Results for collision frequency and electron density show general agreement with computed equilibrium values, and it is suggested that the multiplicity of species in ionized air may be conveniently simplified, without serious error, by considering only molecular nitrogen, atomic oxygen, nitric oxide, ions, and electrons. (auth)

17249

Argentina. Comisión Nacional de Energía Atómica, Buenos Aires.

DISEÑO Y MEDICIONES CON UNA FUENTE DE IONES DEL TIPO DE ARCO COLIMADO EN CAMPO MAGNÉTICO I. Informe No. 7. (Design and Measurements with an Arc-type Ion Source Collimated by a Magnetic Field. [Part I]. Report No. 7). Manlio Abele and Wolfgang Meckbach. 1959. 31p.

An experimental hot-cathode arc discharge-type ion source was constructed. The arc is collimated in a magnetic field and the extraction of the ion beam is axial. De-

tailed measurements of the characteristics of this ion source have been made. The maximum total ion current obtained is 40 ma. There is evidence of secondary electrons whose effects on the measured current had to be eliminated. Calorimetric measurements of the target current are in agreement with the electrical ones. A convenient means of regulation or modulation of the beam current of the source is described. (auth)

17250

Argentina. Comisión Nacional de Energía Atómica, Buenos Aires.

DISEÑO Y MEDICIONES CON UNA FUENTE DE IONES DEL TIPO DE ARCO COLIMADO EN CAMPO MAGNÉTICO II. Informe No. 8. (Design and Measurements with an Arc-type Ion Source Collimated by a Magnetic Field. [Part II]. Report No. 8). Manlio Abele and Wolfgang Meckbach. 1959. 40p.

The construction of the ion source is described. Further investigations were made of the properties of the source improving especially the extracting and focusing of the ion beam, which allowed measurement of practically 100% of the extracted ions on the collecting electrode, even at the maximum current of 40 ma. It seems evident that the limiting factor on the maximum current is not due to the source itself, but rather due to space charge effects in the extracted beam, which tend to deteriorate the focusing and give rise to secondary emission. High-energy secondary electrons which find their way back through the source produce local heating of the filament and instabilities of the arc current. A magnetic analysis of the ion beam shows a maximum percentage of protons of 30% related to the total hydrogen-ion current. Humidity of the input hydrogen gives rise to a strong oxygen peak. (auth)

## Astrophysics and Cosmology

17251 UCRL-Trans-511(L)

COMET TAILS AND SOLAR CORPUSCULAR RADIATION. L. Biermann. Translated by Esther Fultz from Z. Astrophys. 29, 274-86(1951). 19p. JCL.

In stretched-out-comet-tails which are composed of ions ( $\text{CO}^+$ , etc.), the acceleration of elements of the tail was frequently observed to exceed factors of the order 10 to several  $10^3$ . Such high accelerations are not due to the pressure of the sun's radiation on the molecules. A hypothesis is established that these accelerations are caused by the corpuscular radiation of the sun. The solar corpuscular radiation is considered to arise from ions and free electrons in equal number ( $10^3$  to  $10^6 \text{ cm}^{-3}$ ) that are emitted from the sun with regulated velocities of  $10^3 \text{ km/sec}$ ; the temperature of the small particles taken to be  $10^4$ . Under these conditions, the  $\text{CO}^+$  ions originating in the casing of the comet experience accelerations up to  $10^4 \text{ cm/sec}^2$ . The impulse is, for all practical purposes, transmitted only by the free electrons, whose effective collision cross section exceeds the kinetic-gas cross section by several powers of ten. The electric fields that are produced are estimated on the basis of plasma equations. These fields are so adjusted that the free electrons conform almost exactly to the average motion of the solar and molecular ions of the comet. The ions are not notably accelerated or delayed by the electric field. On the basis of this idea of the acceleration mechanism, the observations of Hoffmeister on the condition of the primary train (trail) beam can be understood. In the case of the particle radiation carrying a magnetic field along with it, under certain conditions a still stronger impulse trans-

mission results on the molecular ions. The picture obtained was checked by the example of the comet Whipple-Fedtke (1942 g). The observations showed a very distinct influence of the magnetic storm of March 29, 1943, and a similar effect almost exactly one sun rotation earlier, which apparently was caused by particle radiation emanating from the same center at the sun. (auth)

17252

THE SOURCE OF RADIATION FROM JUPITER AT DECIMETER WAVELENGTHS. 2. CYCLOTRON RADIATION BY TRAPPED ELECTRONS. George B. Field (Princeton Univ., N. J.). *J. Geophys. Research* 65, 1661-71 (1960) June.

One of the mechanisms suggested in a previous paper which could account for the decimeter radiation from Jupiter is examined in detail. A model is proposed in which nonrelativistic electrons are trapped on a magnetic surface in Jupiter's magnetic field, in analogy with the outer radiation belt of the earth. The spectrum and polarization of the cyclotron radiation emitted as the electrons move through the inhomogeneous magnetic field are calculated. The form of the spectrum ( $\lambda_{\gamma}$ ) compares well with the observed one, and the required electron densities are only 0.3% of those observed in the belt around the earth. The required magnetic field is very large—at least 1200 gauss at the poles. It is found that the polarization of the 20-Mc/sec bursts can be explained if the latitude of the emitting region is between 30° and 40°. A suggestion is made about the origin of those bursts in electrical discharges. It is shown that the large magnetic field may be primordial, owing to the high electrical conductivity throughout the planet. Observational tests related to the proposed mechanism are discussed. (auth)

17253

ABUNDANCES OF THE RARE-EARTH ELEMENTS, LANTHANUM TO LUTETIUM, IN CHONDRITIC METEORITES. R. A. Schmitt, A. W. Mosen, C. S. Soffredini, J. E. Lasch, R. A. Sharp, and D. A. Olehy (General Atomic Div., General Dynamics Corp., San Diego, Calif.). *Nature* 186, 863-6 (1960) June 11.

It has been found that relative cosmic abundances vary by a factor of  $\sim 10^{13}$ , and decrease logarithmically and rather smoothly from the lightest to the heaviest elements. Accurate determinations of the abundances of rare earths in primordial matter are required in order to establish empirical relationships among the abundances of elements formed in nucleogenesis. Results of the Allegan and Richardson determinations for two chondritic meteorites are compared to the elemental abundances calculated with the assumption of identical isotopic abundances for rare-earth elements, except unstable promethium, in meteoritic and terrestrial matter. These comparisons are given in tabular form. (B.O.G.)

17254

DOPPLER PHENOMENON IN RADIANT GASEOUS ATMOSPHERES WITH VELOCITY AND DENSITY FIELDS. Louis Gold (Radiation, Inc., Orlando, Fla.). p.813-16 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

A new variant of Doppler line broadening, a so-called gradient-Doppler, is proposed which bears particularly on the interpretation of characteristic line profiles from astrophysical systems. A simple model for the resultant modification of spectra emitted along a velocity and density gradient manifests profiles of unusual character that have

been identified with  $H_{\alpha}$  radiation during limb flare. The theory of gradient-Doppler provides an explanation of the red-shift not founded on abstruse physical principles. Brief note is made of implications relating to the recessional motion of nebulae. Laboratory investigation is suggested on the basis of shock conditions which lend themselves to experimental test of the theory; the requisite spectra may have already been so observed. (auth)

## Cosmic Radiation

17255

ON THE NORTH-SOUTH ASYMMETRY OF COSMIC RAYS NEAR SEA LEVEL AT GREAT ZENITH ANGLES IN HIGH LATITUDES. Väinö Hovi and Asko Aurela (Univ. of Turku, Finland). *Ann. Acad. Sci. Fenniae Ser. A. VI* No. 46, 1-6 (1960). (In English)

The north-south asymmetry of ionizing cosmic rays was measured in Turku, Finland, in the geomagnetic latitude of 58.3°N and at the altitude of 49 m above the sea level at the zenith angle of 80°. The result obtained,  $A_{ns} = 0.107$ , supports Burbury's view of the origin of this asymmetry. (auth)

17256

27-DAY RECURRENCE OF COSMIC-RAY INTENSITY AT THE MINIMUM SOLAR ACTIVITY. Masahiro Kodama (Inst. of Physical and Chemical Research, Tokyo). *J. Geomagnet. Geoelec.* 11, 6-10 (1959). (In English)

A close negative correlation was found to exist between the 27-day recurrence tendency of cosmic rays and that of solar activity. Both recurrences have positive correlation during several months at the minimum solar activity. This phenomenon suggests that there may be at all times some solar emission of cosmic-ray particles, which is not observable except in the short period of minimum solar activity. (auth)

17257

RECOVERY OF COSMIC-RAY INTENSITIES AFTER THE "FORBUSH-TYPE DECREASE." Teiichiro Yagi (Hokkaido Gakugeidai, Sapporo). *J. Geomagnet. Geoelec.* 11, 11-20 (1959). (In English)

By use of Chree's superposed-epoch method, an investigation was made of the recoveries of cosmic-ray intensities, horizontal components of geomagnetic field and sunspot areas following remarkable "Forbush-type decrease." Cosmic-ray intensities and horizontal components of the geomagnetic field show recovery curves which resemble each other, but the curve of sunspot areas remains as a lower level than those of the former two. Cosmic-ray intensities show an exponential recovery until the 26th day, with 14.7 days mean life. On the other hand, sunspot areas show such recovery until only the 11th day, with 7.3 days mean life. On the recovery-curve of logarithms of cosmic-ray intensity decrements, there exists a "knee" at the 4th day. It is proposed that this "knee" corresponds to the escape of the earth from the corpuscular stream ejected from the sun. (auth)

17258

MOTIONS OF SOLAR COSMIC RAYS AND THE PROPERTIES OF THE GENERAL MAGNETIC FIELD OF THE SUN. Kunitomo Sakurai (Kyoto Univ.). *J. Geomagnet. Geoelec.* 11, 21-33 (1959). (In English)

With reference to solar magnetic observations, it is proposed that the sun has a magnetic field of dipole character such that the intensity is about one gauss in the polar latitude regions and its polarity is inverse of the earth's.

If this field results from a magnetic dipole that the sun may have, the value of this dipole moment is estimated as about  $5 \times 10^{22}$  gauss/cm<sup>3</sup>. On the assumption that the magnetic field from this dipole spreads to the outer space surrounding the sun, the orbits of solar cosmic particles were calculated. It is concluded that a solar dipole magnetic field does not exist between the sun and the earth since the existence of this field can not explain cosmic-ray increases associated with large solar flares. Therefore, although the magnetic field extending from the polar regions into outer space is regarded as closing each other in this space, the features of this field may be remarkably different from the dipole character. A probable configuration in the interplanetary space of the solar general magnetic field is introduced and discussed. (auth)

## 17259

PRELIMINARY RESULTS FROM THE SPACE PROBE PIONEER V. C. Y. Fan, P. Meyer, and J. A. Simpson (Univ. of Chicago). *J. Geophys. Research* 65, 1862-3 (1960) June.

Preliminary results obtained by Pioneer V are discussed. On March 31, 1960, a sudden galactic cosmic-ray intensity decrease occurred at the earth and at Pioneer V ( $5 \times 10^8$  km from the earth) of about the same magnitude. The direct detection of particles accelerated in solar flares was observed. Evidence was found for the solar production of energetic electrons by processes other than solar flares. (B.O.G.)

## 17260

LARGE COSMIC RAY INTENSITY FLUCTUATIONS IN THE STRATOSPHERE. A. N. Charakhch'yan, V. F. Tulinov, and T. N. Charakhch'yan. *Zhur. Ekspol'. i Teoret. Fiz.* 38, 1031-6 (1960) Apr. (In Russian)

The energy spectrum of an additional proton flux which exceeded the normal value by more than 20 times was derived on basis of stratosphere measurements. The exponent of the differential spectrum is equal to 6.0 in the 120 to 170 Mev energy range. It is suggested that these protons are due to corpuscular beams frozen in magnetic fields emitted during the solar chromosphere flare on May 10, 1959. (auth)

## 17261

MULTIPLE PRODUCTION OF JET PARTICLES IN PERIPHERAL COLLISIONS. Yu. A. Romanov and D. S. Chernavskii. *Zhur. Ekspol'. i Teoret. Fiz.* 38, 1132-9 (1960) Apr. (In Russian)

Peripheral collisions of high-energy nucleons ( $E_{lab} > 10^{12}$  ev) are considered. The Weizsacker—Williams method is employed; thus one can classify peripheral collisions and describe the peculiarities of each type of interaction. One of the simplest variants (peripheral single-meson interaction) is calculated by perturbation theory methods. (auth)

## 17262

DISINTEGRATION OF COSMIC RAY NUCLEI BY SOLAR PHOTONS. N. M. Gerasimova and G. T. Zatsepin. *Zhur. Ekspol'. i Teoret. Fiz.* 38, 1245-52 (1960) Apr. (In Russian)

A calculation is made of the effect of disintegration of cosmic nuclei in the field of solar photons leading to formation of correlated showers in the atmosphere. The energy of the disintegrated nuclei is found to be of the order of  $10^{16}$  ev per nucleon and their flux is of the order of  $10^{-4}$  to  $10^{-5}$  km<sup>-2</sup> hour<sup>-1</sup> sterad<sup>-1</sup>. As a result of divergence of the photonuclear disintegration products before they enter the atmosphere the distances between the cores turn out to be of the order of approximately 1 km. (auth)

## 17263

DISTRIBUTION OF THE TRANSVERSE MOMENTUM OF SHOWER PARTICLES IN JETS. E. G. Boos and Zh. S. Takibaev. *Zhur. Ekspol'. i Teoret. Fiz.* 38, 1276-84 (1960) Apr. (In Russian)

Experimental data are presented on the distribution of the transverse momentum values of secondary shower particles in jets produced by cosmic rays. Transverse momentum distributions which follow from various theories and from various phenomenological descriptions of multiple production of mesons are analyzed and systematized. Comparison with the experiments narrows the possible choice of a scheme for description of the elementary multiple meson production process. (auth)

## 17264

TRAPPED RADIATION IN THE EARTH'S MAGNETIC FIELD. S. F. Singer (Univ. of Maryland, College Park). p.1187-90 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Problems of injection, lifetime, and possible heating of plasmas in the earth's magnetic field are discussed. Injection can take place by solar corpuscular streams which perturb the magnetic field, or by means of neutrons which decay within the field, or by the direct release of charged particles within the earth's magnetic field, for example by means of an accelerator carried to high altitudes. The behavior of the trapped particles shows many interesting features which are important for laboratory plasmas confined in a mirror geometry. To calculate the scattering, energy loss, and lifetime of a particle, new techniques must be adopted. Phenomena occur in naturally trapped plasmas which have not been sufficiently studied either in nature or in the laboratory: Instabilities set up by trapped particles, their bunching, and the emission of electromagnetic waves of low frequency; interaction between charged particles and hydromagnetic waves leading to particle acceleration which eventually manifests itself in the form of aurora. (auth)

## 17265

Argentina. Comisión Nacional de Energía Atómica, Buenos Aires.

EQUIPOS ELECTRONICOS DEL AÑO GEOFÍSICO INTERNACIONAL PARA RADIACIÓN CÓSMICA. Informe No. 30. (Electronic Equipment for Cosmic Radiation Study in the International Geophysical Year. Report No. 30). Horacio Manifesto. 1960. 24p.

A description is given of instrumentation developed to carry out the cosmic ray study program for the International Geophysical Year 1957-58. Circuit and operation of the equipment are presented in detail. (auth)

## Criticality Studies

## 17266 HW-37952

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

NUCLEAR SAFETY SPECIFICATIONS FOR FUEL ELEMENT MANUFACTURING PROCESSES. Oct. 28, 1955. Decl. Apr. 28, 1960. 19p. Contract [W-31-109-Eng-52]. OTS.

Nuclear safety specifications for storage, handling, or transfer of enriched uranium slugs depend upon slug arrangement and geometry, the presence of a moderator such as water or wood, and the presence of other fis-

sionable materials and reflectors. Specifications are given for enriched I and E uranium slugs, solid uranium slugs of two types, and aluminum-uranium alloy slugs. (M.C.G.)

17267 HW-41899

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

NUCLEAR SAFETY OF VESSELS IN ARRAYS. N. Ketz-lach. Mar. 13, 1956. Decl. June 10, 1960. 9p. Contract W-31-109-Eng-52. OTS.

The effects of interaction between vessels or units containing fissionable materials are important for safe handling, storage, and shipping. Expressions for the effect of neutron interaction on criticality were derived for cases of bare and tamped spheres as well as tamped, infinitely tall cylinders containing fissionable material. (C.H.)

17268 HW-65207

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

PLUTONIUM OXIDE-PLASTIC MIXTURES FOR CRITICAL MASS STUDIES. H. W. Crocker. May 12, 1960. 15p. Contract AT(45-1)-1350. OTS.

Mixtures of  $\text{PuO}_2$  and polyethylene, methyl methacrylate, or paraffin compacted in containers were considered for use in highly concentrated plutonium systems of known H/Pu atomic ratio to be used in critical mass experiments. The compression molding method used for the mixed fuel fabrication is described. Limitations on the practical use of the cylinders for critical mass studies are noted, and a method for separating  $\text{PuO}_2$  from polyethylene mixtures is included. (J.R.D.)

17269 KS-347

Carbide and Carbon Chemicals Co. [K-25 Plant], Oak Ridge, Tenn.

THE INTERACTION OF BARE SYSTEMS OF CONTAINERS. PART II. L. Geller. Dec. 16, 1952. Decl. Mar. 7, 1960. 26p. OTS.

A systematic criterion for determining sub-critical configurations of fissile material container systems is discussed. The criterion is applied to a number of cases. (J.R.D.)

17270 YAEC-152

Westinghouse Electric Corp. Atomic Power Dept., Pittsburgh.

CRITICAL MASSES AND LATTICE PARAMETERS OF  $\text{H}_2\text{O}-\text{UO}_2$  CRITICAL EXPERIMENTS. A COMPARISON OF THEORY AND EXPERIMENT. W. H. Arnold, Jr. Nov. 1959. 47p. For Yankee Atomic Electric Co. Contract AT(30-3)-222, Subcontract No. 1. OTS.

A semi-empirical method of performing lattice calculations in  $\text{UO}_2-\text{H}_2\text{O}$  cores is described which was used in the design of Yankee core 1. Calculated results using this method give close agreement with experimental results from the Bettis TRX facilities, from the Yankee and BR-3 critical experiments, and from a critical experiment performed for the NSS Savannah. Although the semi-empirical method gives adequate agreement, another system of calculation is presented which uses the MUFT code and has a somewhat firmer theoretical justification. It should prove valuable in the design of future cores. (auth)

## Elementary Particles and Radiations

17271 MURA-574

Midwestern Universities Research Assn., Madison, Wis. ON THE NEUTRINOS EMITTED IN  $\beta$ -DECAY AND  $\mu$ -

CAPTURE. S. P. Rosen. [1960]. 5p. Contract AT(11-1)-384. OTS.

The assumption that the neutrinos  $\nu_1$  and  $\nu_2$  emitted in  $\mu$ -capture and  $\beta$ -decay, respectively, have opposite helicity is shown to be consistent with experimental data. A crucial test of this assumption is shown to be the measurement of the helicity of muons emitted in  $(\pi-\mu)$ -decay. (auth)

17272 NP-8710

Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Theoretical Physics.

ON THE STATE OF A FERMI-SYSTEM WITH CORRELATION OF PAIRS OF PARTICLES WITH PARALLEL SPINS. II. THERMODYNAMICS. Zygmunt Galasiewicz. 1960. 11p. (E-495).

The thermodynamics of the "anomalous" state of a Fermi-system (in which the correlation of the pairs of particles with parallel spins is taken into account) is investigated. The transition temperature  $T_c$  to the "anomalous" state and the temperature dependence of the specific heat for  $T \sim 0$  and  $T \sim T_c$  are found. For  $T = T_c$  the specific heat has a jump. In addition the formulas for paramagnetic susceptibility for  $T \sim 0$  and  $T \sim T_c$  are obtained. (auth)

17273 NP-8712

Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of High Energy.

ON CHARGE EXCHANGE AND SCATTERING IN REACTIONS ACCOMPANIED BY PION PRODUCTION AT HIGH ENERGIES. V. N. Streletsov. 1960. 5p. (D-472).

The interactions of fast particles with nucleons accompanied by the production of a  $\pi$  meson are considered. It is assumed that the nucleon dissociation follows the scheme  $N \rightarrow N + \pi$ . (W.D.M.)

17274 NP-8713

Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of High Energy.

AN ANALYSIS OF 'ANOMALOUS' COSMIC RAY  $V^0$ -EVENTS IN VIEW OF A POSSIBLE EXISTENCE OF A NEUTRAL D-MESON. I. V. Chuvilo. 1960. 9p. (E-497).

The existence of a neutral D meson with the decay mode  $D^0 \rightarrow K^+ + \pi^- + Q$  is considered. From papers published from 1952 to 1957, 'anomalous'  $V^0$  decays which could not be identified as  $\Lambda^0$  or  $\Theta^0$  events are analyzed. (W.D.M.)

17275

PHASE SHIFT ANALYSIS OF COMBINED COULOMB AND NUCLEAR SCATTERING. T. Tietz (Univ. of Łódź, Poland). *Acta Phys. Acad. Sci. Hung.* 11, 235-8(1960). (In English)

An exact formula is derived for the phase shift of combined Coulomb and nuclear scattering. The formula derived for the above-mentioned phase shift allows calculations of the phase shift exactly if a sufficiently large zero of the solution of the Schrödinger equation containing Coulomb and nuclear potential is known. The above-mentioned zero has to be computed numerically. (auth)

17276

ELASTIC SCATTERING OF ELECTRONS BY AN APPROXIMATE POTENTIAL OF THE SELF-CONSISTENT FIELD FOR IONS IN THE FIRST AND SECOND BORN APPROXIMATION. T. Tietz (Univ. of Łódź, Poland). *Acta Phys. Acad. Sci. Hung.* 11, 259-64(1960). (In English)

Using an analytical expression for the atomic field proposed by Fogel, calculations are made for the differential scattering cross sections for elastic scattering of electrons in the first and second Born approximation. The

integrals were calculated by the technique given by Dalitz and Vachaspati. (auth)

17277

ON THE INTEGRATION OF A CERTAIN MATRIX ELEMENT  $\langle 0 | f^{(2)}(x) | q, k \rangle$  IN THE PERTURBATION APPROACH OF QUANTUM ELECTRODYNAMICS. H. Wilhelmsson and A. Kerman (Nordisk Institut for Teoretisk Atomfysik, Copenhagen). Arkiv Fysik 17, 149-56(1960). (In English)

A certain problem in the solution of the perturbation equations for the coupling of Dirac and electromagnetic fields (electron-photon) is treated. This problem is the integration of a difficult matrix in the second-order approximation of the operator  $f(x)$  in the Heisenberg representation. Hilbert transformations are used. (D.L.C.)

17278

REMARKS ON THE REACTIONS OF RADICALS OR ACTIVATED WATER MOLECULES IN THE TRACKS OF IONIZING PARTICLES. Z. Tauer, F. Duhajský, and J. Bednář (Militärische Akademie "A. Zapotocky," Brno). Collection Czechoslov. Chem. Commun. 25, 1391-6(1960) May. (In German)

The yield of nitrite in  $\beta$  irradiation of concentrated nitrate solutions was measured. The nitrite in these solutions is produced by the indirect effects of radicals or, in a given case, activated water molecules and by the direct radiation effect on nitrate ions. The effect of pH probably becomes important only in the secondary reactions beyond the path of the ionizing particle. (tr-auth)

17279

THE NON-RELATIVISTIC WAVE FUNCTIONS ASSOCIATED WITH THE EXTENDED PARTICLE. Pierre Hillon and Jean-Pierre Vigier. Compt. rend. 250, 3131-3(1960) May 9. (In French)

The non-relativistic wave mechanics of extended particles is characterized by its invariance under the group of Galilean transformations with rotation which is the direct product of the Galileo group and the  $R_3$  group of tridimensional rotations. From the direct product of the irreducible representations of these last two groups, the non-relativistic wave functions associated with the extended particle are deduced. (tr-auth)

17280

TRANSIENT PHENOMENA IN BRANCHING PROCESSES WITH  $n$  TYPES OF PARTICLES. V. P. Chistyakov (Lomonosov Moscow State Univ.). Doklady Akad. Nauk S.S.R. 131, 522-4(1960) Mar. 21. (In Russian)

The branching process  $\lambda = 0$  divides into two different branching processes with transitional phenomena appearing as  $\lambda \rightarrow 0$ . An analysis is made of finite theorems with  $t \rightarrow \infty$ ,  $\lambda \rightarrow 0$ , similar to theorems developed by B. A. Sevast'yanov for processes dealing with one type of particles. The results for  $\lambda = 0$  processes are derived by specially developed theorems. (R.V.J.)

17281

MESIC GROUP AND CONSERVATION OF PARITY. A. Pètermann. (European Organization for Nuclear Research, Geneva) and Henri Ruegg (Université, Geneva). Hely. Phys. Acta 33, 143-60(1960). (In French)

A principle of invariance under a continuous local group of transformations, the mesic group, is investigated. This principle has the following influences: 1. For the pseudo-scalar Yukawa interaction of two Fermions with the pseudo-scalar  $\pi$ -meson it entails PC invariance. 2. If the Fermions have equal bare masses with respect to electromagnetic interaction (a hypothesis which is plausible for the nucleons), the principle imposes, for the  $ps$  interaction with  $\pi$ ,

the conservation of isotopic spin and separate P and C invariance. 3. For the Fermi interactions of the pairs ( $pn$ ), ( $p\mu^-$ ), ( $p\pi^-$ ), etc., it involves V-A coupling, with nonconservation of parity. Arguments leading to this principle are based on a generalization of the demonstration of the Dyson-Foldy equivalence theorem as given by Stueckelberg and Pètermann. (auth)

17282

BETA PARTICLE TRANSMISSION CURRENTS IN SOLID DIELECTRICS. Bernhard Gross (Instituto Nacional de Tecnología, Rio de Janeiro) and Arthur Bradley and Arthur P. Pinkerton (Radiation Research Corp., New York). J. Appl. Phys. 31, 1035-7(1960) June.

The current from a beta particle source measured through a thin dielectric cannot be predicted simply from the absorption curve. A model is considered in which the space charge formation in the medium results in a component of current in addition to that of the betas transmitted. Calculations developed from this model give a close approximation to experimental results. (auth)

17283

RESONANCE ABSORPTION IN DENSELY ARRANGED SMALL BLOCKS. Yu. (J.) V. Petrov. Kernenergie 1, 128-9(1958) Feb. (In German)

One of the most important quantities which characterize the developmental possibility of a nuclear chain reaction in a U-moderator system is the resonance absorption probability of neutrons in  $U^{238}$  by slowing down from fission energy to thermal energy. The formula for resonance absorption of neutrons in small blocks as derived by Gurevich and Pomeranchuk is generalized for the case of a lattice of densely arranged blocks. The absorption is considered on the basis of repeated collisions of the neutrons on the block. The estimates produced differ from those of the Kurevich-Pomeranchuk formula by the fractional coefficient for absorption in the block. (tr-auth)

17284

THE CONVERSION OF THE ENERGY OF  $\beta$ -PARTICLES TO ELECTRON ENERGY IN GERMANIUM CRYSTALS WITH  $pn$  JUNCTION. B. M. Vul, V. S. Vavilov, L. S. Smirnov, G. N. Galkin, V. M. Patskevich (Packevič), and A. V. Spitsyn (Spicyn). Kernenergie 1, 279-82(1958) Apr. (In German)

Results are given from studies of the conversion of fast electron energy to electrical energy by Ge crystals with  $pn$  junctions. Data are also given on the efficiency of the conversion and on its dependence on the intensity of the absorbed radiation and the integral dose. It is further explained that the increase of recombination rate of electrons and holes at the recombination levels of the structural defects produced by radiation is the principal factor in the reduction of conversion efficiency. The change in electrical equivalent conductivity and the mobility of the charge carriers play a subordinate role. The possibility of restoration of the original properties of the crystal by heat treatment is pointed out, and ionization curves for monoenergetic electron beams in Ge are given. (tr-auth)

17285

AN EXTENSION OF THE TRANSFER MATRIX METHOD TO A BEAM TRANSPORT SYSTEM CONTAINING A SOLENOID. D. N. Edwards and B. Rose (Atomic Energy Research Establishment, Harwell, Berks, Eng.). Nuclear Instr. & Methods 7, 135-44(1960) May. (In English)

The transfer matrix method of calculating beam transport problems is outlined, and extended to the case in which one of the elements is a solenoid, as is used in certain

polarization experiments. The theoretical results are compared with measurements made with a proton beam and semi-quantitative agreement found. (auth)

17286

DERIVATION OF THERMAL NEUTRON SPECTRA FROM TRANSMISSION DATA. Edward A. Burke and Lester F. Lowe (Air Force Cambridge Research Center, Bedford, Mass.). Nuclear Instr. & Methods 7, 193-6(1960) May. (In English)

A method formerly used for deriving x-ray spectra from transmission data was employed to determine the spectrum of thermal neutrons. In this method a transmission curve of a neutron beam is obtained, a suitable Laplace transform fitted to the curve, and the spectrum derived from the inverse transform. An experimental test yielded results in reasonable agreement with theoretical expectations. The relative simplicity of the equipment and procedures employed should make this method a useful supplement to standard techniques. (auth)

17287

FURTHER COMMENTS ON ERRORS IN POLARIZATION MEASUREMENTS. Edward J. Burge (King's Coll., London). Nuclear Instr. & Methods 7, 221-2(1960) May. (In English)

A method was pointed out previously for reducing the fractional error in polarization measurements of a beam of particles. An expression was given for the root mean square fractional error. This suggested method is not strictly correct, as the errors are not independent, and a derivation which aims at avoiding this difficulty has been made. The expression obtained is not significantly different for values of  $P$  less than about 0.5, but yields interesting values for  $f$  as  $P$  approaches unity. (B.O.G.)

17288

INTRODUCTION OF MANY-PARTICLE VARIABLES FOR THE TREATMENT OF SPECIAL TRANSLATIONALLY INVARIANT MANY-BODY PROBLEMS. P. Möbius (Technische Hochschule, Aachen). Nuclear Phys. 16, 278-303 (1960) May (1). (In English)

An attempt is made to treat special translationally invariant many-body problems by coordinate transformations introducing many-particle variables. These are adapted coordinates of such kind that the condition of translational invariance and the Pauli principle can be satisfied automatically. They are homogeneous functions of the particle coordinates obeying certain differential equations. The Schrödinger equation is transformed into these variables. There exist examples of systems of interacting particles which can be separated exactly in the many-particle variables but not in the particle coordinates. (auth)

17289

PROTON-PROTON SCATTERING AT 98 AND 142 MEV. A. E. Taylor, E. Wood, and L. Bird (Atomic Energy Research Establishment, Harwell, Berks, Eng.). Nuclear Phys. 16, 320-30(1960) May (1). (In English)

The differential cross section and the polarization in proton-proton scattering were measured over the angular range 5 to 90° cm at 98 and 142 Mev. For angles greater than 37° cm the variation of the differential cross section can be expressed as  $4.01 \pm 0.19(1 - (0.02 \pm 0.045) \cos^2\theta)$  at 142 Mev and as  $4.41 \pm 0.21(1 + (0.02 \pm 0.07) \cos^2\theta)$  at 98 Mev, and the polarization cross section  $P(d\sigma/d\omega)/\sin 2\theta$  can be expressed as  $(0.806 \pm 0.021) + (0.339 \pm 0.063) \cos^2\theta$  and as  $(0.54 \pm 0.05) - (0.04 \pm 0.12) \cos^2\theta$  at 142 and 98 Mev, respectively. (auth)

17290

POLARIZATION OF 1.0-MEV NEUTRONS SCATTERED FROM DEUTERIUM. S. E. Darden, C. A. Kelsey, and T. R. Donoghue (Univ. of Notre Dame, Ind.). Nuclear Phys. 16, 351-6(1960) May (1). (In English)

Neutron polarization produced in the scattering of 1-Mev neutrons by deuterons was measured. Asymmetry measurements were performed for c.m. scattering angles of 70, 110, and 140° using the method of Levintov, Miller, and Shamshov. The polarization was found to be small and opposite in sign to that predicted by Delves and Brown. An asymmetry measurement was also carried out at a c.m. scattering angle of 110° for 2-Mev neutrons. (auth)

17291

ELEMENTARY FIELDS AND IRREDUCIBLE REPRESENTATIONS OF THE LORENTZ GROUP. P. Hillion and J. P. Vigier (Institut Henri Poincaré, Paris). Nuclear Phys. 16, 360-73(1960) May (1). (In English)

With the help of a new representation of the Lorentz group in terms of complex relativistic Euler angles, finite-dimensional vector spaces irreducible under Lorentz transformations were determined. If every elementary particle family is associated with such a space, wave equations are obtained. (auth)

17292

THE INTERACTION AND DECAY OF  $K^-$ -MESONS IN PHOTOGRAPHIC EMULSION. PART III.  $K^-$ -COLLABORATION. D. Evans, F. Hassan, K. K. Nagpaul, and D. J. Prowse (Bristol Univ., Eng.); M. René (Université Libre, Brussels); G. Alexander and R. H. W. Johnston (Inst. of Advanced Studies, Dublin); D. Keefe (University Coll., Dublin); D. H. Davis, W. B. Lasich, M. A. Shaukat, and F. R. Stannard (University Coll., London); A. Bonetti and C. Dilworth (Università, Milan and Istituto Nazionale di Fisica Nucleare, Milan); and M. Merlin and A. Salandin (Università, Padua and Istituto Nazionale di Fisica Nucleare, Padua). Nuovo cimento (10) 15, 873-98(1960) Mar. 16. (In English)

The mean free path for  $K^-$  interaction in flight 10 to 80 Mev with hydrogen and with the complex nuclei in emulsion are compared with other recent experimental data. A number of  $\Sigma$ -hyperons are also investigated. From favorable examples of  $\Sigma^+$ -p decay recorded in the emulsion the  $\Sigma^+$  mass is estimated as  $M_{\Sigma^+} = 2327.2 \pm 1.0$  m<sub>e</sub> and from the hydrogen capture ( $K^- + H$ ) events the mass difference ( $M_{\Sigma^-} - M_{\Sigma^0}$ ) is found to be  $14.6 \pm 1.1$  m<sub>e</sub>. Lifetime estimates are also given for the charged  $\Sigma$  hyperons: a) The best estimate for the  $\Sigma^+$  lifetime is obtained using only events in which the decay proton is emitted forward in the center-of-mass system. Thus  $\tau^+ = 0.82 \times 10^{-10}$  sec. b) A representative value for the hypothetical  $\Sigma^-$  lifetime as determined from 70 selected  $\Sigma^-$  decays is  $0.71 \times 10^{-10}$  sec. The effective lifetime appears to remain of the order of the  $\Sigma^+$  lifetime, even in samples containing widely different proportions of  $\Sigma^-$  hyperons. Although values are greater than the lifetimes previously reported in emulsion experiments, it still appears possible that a genuine anomaly may exist. The observed numbers of secondary interactions by charged particles emitted from the  $K^-$ -capture stars may be accounted for on the basis of proton interactions, although some contribution from deuterons is not excluded. One definite example of a fast  $\Sigma$  interaction (visible energy release 129 Mev) has been found in a length of 70 cm of track registered in the emulsion. The number of single scatterings in 18 cm of  $\Sigma^-$  and 25 cm of  $\Sigma^+$  hyperon track in emulsion (energy interval 5 to 100 Mev) is compared with that expected for Coulomb scat-

tering by a point nucleus. Only a slight possible indication of the nuclear interaction of the  $\Sigma^+$ -hyperon is demonstrated with the few data at present available. In  $K^-$ -interactions giving  $(\Sigma + \pi)$  some 45  $\Sigma_p^+$  and 47  $\Sigma_p^+$  decays were also examined for possible polarization of the decay with respect to the  $(\Sigma, \pi)$  plane of production. (auth)

17293

INELASTIC SCATTERING OF ANTI-PROTONS BETWEEN 30 AND 250 MEV. G. Baroni, C. Castagnoli, A. Manfredini, and V. Rossi (Università, Rome and Istituto Nazionale di Fisica Nucleare, Rome). Nuovo cimento (10) 15, 899-906 (1960) Mar. 16. (In Italian)

The inelastic scattering of antiprotons from emulsion nuclei is studied in the energy range from 30 to 250 Mev. The cross section for this process is redetermined on the basis of a criterion. The result  $\sigma_1 = 85 \pm 20$  mb is confirmed, a value which appreciably differs from that of other authors:  $\sigma_1 = 42 \pm 11$  mb. This is due to a more efficient criterion for the identification of the events, based on gap measurements. The inelastic scattering is then analyzed by means of the optical model, and a value can be given for the effective cross section of  $\bar{p}$  against bound nucleons:  $\sigma_{\text{eff}} = 180 \pm 50$  mb. (auth)

17294

NOTE ON POSSIBLE RARE DECAY MODES FOR ELEMENTARY PARTICLES. E. Galzenati, M. Marinaro, and S. Okubo (Università, Naples). Nuovo cimento (10) 15, 934-6 (1960) Mar. 16. (In English)

Some bound-state decay processes of elementary particles, like a neutron decaying into a hydrogen-atom, are investigated. It is found that they may happen in a rate of one to a million compared to the usual modes. (auth)

17295

ON THE POLARIZATION OF PHOTONS ELASTICALLY SCATTERED BY MERCURY ATOMS. G. Böbel and G. Passatore (Università, Genoa and Istituto Nazionale di Fisica Nucleare, Genoa). Nuovo cimento (10) 15, 979-82 (1960) Mar. 16. (In English)

The results of a study of the polarization of photons elastically scattered by mercury atoms are reported. A matrix is derived for finding the polarization from that of the incident photon beam. Curves of the degree of polarization vs scattering angle are given for photon energies of 0.32, 0.64, 1.28, and 2.56 mev<sup>2</sup> and the following types of polarization: (1) linear polarization for unpolarized incident beam, (2) circular polarization for linearly polarized incident beam, and (3) linear polarization taking Rayleigh and Thomson scattering into account. (D.L.C.)

17296

ANTIHYPERON PRODUCTION IN ANTI-NUCLEON-NUCLEON COLLISIONS NEAR THRESHOLD. G. Domokos (Central Research Inst. for Physics, Budapest). Nuovo cimento (10) 15, 983-5 (1960) Mar. 16. (In English)

The possibility of hyperon-antihyperon pair production in nucleon-antinucleon collisions is studied theoretically using the T matrix of nucleon-antinucleon interactions, neglecting electromagnetic interactions and meson (K) production. The numerical data for the computation of the cross sections of production are tabulated for the hyperon pairs  $\bar{\Lambda}\Lambda$ ,  $\bar{\Lambda}\Sigma$ ,  $\bar{\Sigma}\Lambda$ ,  $\bar{\Sigma}\Sigma$ , and  $\bar{\Xi}\Xi$ . The cross section of  $\bar{\Lambda}\Lambda$  production is computed to be ca. 48 mb, which is in good agreement with the value of 50 mb reported for seven observed  $\bar{\Lambda}\Lambda$  events. The cross sections for the other hyperon pairs are nearly zero. (D.L.C.)

17297

K-MESON PARITY FROM DISPERSION RELATIONS.

F. Selleri (European Organization for Nuclear Research, Geneva). Nuovo cimento (10) 15, 986-90 (1960) Mar. 16. (In English)

The problem of studying meson (K) parity using dispersion relations for the forward  $K^+ - p$  scattering amplitude (Amati's approach) is discussed. It was shown by Amati that if the cross section ( $\sigma^+$ ) of  $K^+ - p$  scattering at low energy is assumed to be constant, there is evidence for a pseudoscalar K with respect to both  $\Lambda$  and  $\Sigma$  hyperons. In this paper, however, the possibility of a scalar or pseudoscalar K with respect to both  $\Lambda$  and  $\Sigma$  hyperons was found to be excluded for the case of nonconstant  $\sigma^+$ . The effects of unphysical region contributions were studied and found to be negligible. (D.L.C.)

17298

A POSSIBLE NON-UNIFORM MOTION OF A FREE PARTICLE IF ITS SCALAR PROPER FIELD IS TAKEN INTO ACCOUNT. I. Abonyi (Eötvös Univ., Budapest). Nuovo cimento (10) 15, 991-2 (1960) Mar. 16. (In English)

Several possible solutions to P. Havas' relativistic equation for the motion of a point particle subjected to external and proper scalar fields are discussed. The condition  $\chi = 0$  (1/h times the quantum rest mass of the scalar field) gives a self-accelerating solution which indicates that, for  $\chi \neq 0$ , oscillating solutions exist, similar to the variable motion of the free electron. (D.L.C.)

17299

A POSSIBLE EXAMPLE OF THE MUON RADIATIVE DECAY WITH INTERNAL CONVERSION OF THE  $\gamma$ -RAY. Valerie Mayes (Univ. of Bristol, Eng.). Phil. Mag. (8) 5, 297-8 (1960) Mar.

An area scan for  $\pi^- - \mu^- - e^-$  was made in a stack exposed to cosmic rays at 13 km. An event was found in which three relativistic electrons escaped from the decay of the  $\mu^-$  meson at rest. The nature of the  $\mu$  meson was established from its origin and its range, 613  $\mu$ . The short length of the tracks and their steepness made energy determinations difficult. The probability of finding a background electron pair within 10 cubic microns of the  $\mu^-$  decay was determined from the density of  $\pi^-$  in the emulsion and was of the order  $10^{-3}$  per  $\mu^-$  meson, i.e., several orders of magnitude smaller than the theoretical probability of radiative decay with internal conversion. (B.O.G.)

17300

COMPLETE DETERMINATION OF POLARIZATION FOR A HIGH-ENERGY DEUTERON BEAM. Janice Button (Univ. of California, Berkeley) and Ronald Mermot (European Organization for Nuclear Research, Geneva). Phys. Rev. 118, 1333-44 (1960) June 1.

Double-scattering measurements were made which yielded all parameters necessary to describe completely the interaction of the deuteron with complex nuclei. Deuterons of 410 and 420 Mev were scattered from beryllium and carbon, respectively. Tensor components of polarization, which should appear in the scattering of spin-1 particles and which were unobservable at low energies, were determined to be appreciably different from zero. The usual vector spin-polarization normal to the plane of scattering was found to reach a maximum of about 70%. The impulse approximation was employed to obtain estimates of deuteron cross section and polarization on the basis of nucleon scattering data. (auth)

17301

ELECTROMAGNETIC CORRECTIONS TO THE RATIO  $\sigma(p + d \rightarrow H^3 + \pi^+)/\sigma(p + d \rightarrow He^3 + \pi^0)$ . H. S. Köhler (European Organization for Nuclear Research, Geneva). Phys. Rev. 118, 1345-50 (1960) June 1.

Electromagnetic corrections to the ratio between charged and uncharged pions produced along with either a triton or helium-3 from 600-Mev protons incident on deuterium were estimated. It was found that the main correction comes from the difference in triton and helium-3 wave functions. It was not found possible to correct unambiguously for the effects of mass difference between charged and uncharged pions. An enhancement of around 10% of positive pions was obtained with an estimated uncertainty of  $\pm 3\%$ . The result agrees with experiments at CERN. (auth)

## 17302

INTERACTIONS OF FAST  $\mu$  MESONS IN LEAD WITH SMALL-ENERGY TRANSFER. J. de Pagter and R. D. Sard (Washington Univ., St. Louis). *Phys. Rev.* **118**, 1353-63 (1960) June 1.

With the Pb target material divided into 1.27-cm slabs between hodoscoped Geiger tubes and surmounted by a magnet cloud chamber, a study was made of the interactions of fast  $\mu$  mesons in which at least one evaporation neutron is produced and no additional charged particles emerge from the slab. The cross section-average neutron multiplicity,  $\sigma \bar{m}$ , is  $(15.2 \pm 2.1) \times 10^{-29}$  cm<sup>2</sup> per nucleon. From hodoscope observations without neutron coincidence it is found that for an electron-initiated shower to stay concealed in a 1.27-cm Pb plate its energy must be less than about 100 Mev. With the help of "approximation B" track length theory and experimental photonuclear neutron yields, it was calculated that hidden knock-on showers contribute  $(5.8 \pm 1.2) \times 10^{-29}$  to the total yield  $\sigma \bar{m}$  (cross section times average multiplicity), leaving  $(9.4 \pm 2.4) \times 10^{-29}$  cm<sup>2</sup> per nucleon as the result for the direct  $\mu$ -meson nuclear interaction. This analysis is supported by the agreement between the number of visible showers observed and calculated. The neutron yield in the direct interaction is found to increase with  $\mu$ -meson momentum. The Weizsäcker-Williams approximation is used to calculate the effect expected from the interaction between the electric charge of the  $\mu$  meson and the nucleons. Within the rather large uncertainties involved in the use of this approximation, there is excellent agreement with the experimental results. (auth)

## 17303

PION PRODUCTION BY PIONS. Walton A. Perkins, III, John C. Caris, Robert W. Kenney, and Victor Perez-Mendez (Univ. of California, Berkeley). *Phys. Rev.* **118**, 1364-70 (1960) June 1.

A liquid hydrogen target was bombarded by negative pions of energies 260, 317, 371, and 427 Mev. Positive pions from the reaction  $\pi^- + p \rightarrow \pi^+ + \pi^- + n$  were detected by the use of a counter telescope, that selected the  $\pi^+$  by its characteristic  $\pi-\mu$  decay. With the 260-Mev beam,  $\pi^+$  mesons were counted at 90° in the laboratory system. At 317, 371, and 427 Mev, the differential cross section was measured for  $\pi^+$  mesons emitted at 60°, 90°, 125°, and 160° in the center-of-mass system. The angular distributions are nearly isotropic at 317 and 371 Mev but are peaked forward at 427 Mev. The total cross sections are  $0.14 \pm 0.10$  mb at 260 Mev,  $0.71 \pm 0.17$  mb at 317 Mev,  $1.93 \pm 0.37$  mb at 371 Mev, and  $3.36 \pm 0.74$  mb at 427 Mev. These results indicate a much larger cross section than the theoretical prediction based on the static model. Reasonable agreement can be obtained by the inclusion of a pion-pion interaction in the production mechanism. (auth)

## 17304

HIGH-ENERGY NEUTRON BEAM OF 45% POLARIZATION. Douglas Miller and Russell K. Hobbie (Harvard Univ., Cambridge, Mass.). *Phys. Rev.* **118**, 1391-6 (1960) June 1.

A beam of polarized neutrons was produced by allowing the 164-Mev internal proton beam of the Harvard synchrocyclotron to strike a beryllium target. The neutrons produced in the forward direction are then polarized by scattering from carbon at 15°. When neutrons of energy greater than 110 Mev are selected by the detection process, an average beam energy of 124-Mev results. An intensity of  $2.9 \times 10^5$  neutrons/in.<sup>2</sup> min through 2 in. by 6-in. collimator has been obtained, with a polarization  $0.447 \pm 0.020$ . The shielding techniques are also discussed. (auth)

## 17305

PUPPI-STANGHELLINI DISCREPANCY. H. P. Noyes (Univ. of California, Livermore) and D. N. Edwards (Univ. of Liverpool). *Phys. Rev.* **118**, 1409-16 (1960) June 1.

In order to establish the extent of the disagreement between the pion-nucleon forward-scattering-amplitude dispersion relations and experiment in a statistical sense, the uncertainty in the dispersion integrals and S-wave scattering lengths is systematically included in the analysis. To accomplish this, the total cross sections below 335 Mev were fitted by a Chew-Low P-wave resonance, phenomenologically modified, and the error matrix for the parameters calculated. The fit to the total cross sections is statistically at least as good as the Anderson parameterization used in previous work. Ignoring forward scattering amplitudes above 220 Mev because of D-wave uncertainties, it was found that there is less than a 4½% probability that the published data are compatible with a unique value for the pion-nucleon coupling constant  $f^2$ , and that no adjustment of the S-wave scattering lengths can remove the discrepancy. However, if the  $\pi^-$  forward-scattering amplitudes measured by Ashkin et al., at 150 and 170 Mev are abandoned in favor of the values recently obtained by Kruse and Arnold at 130 and 152 Mev, the probability rises to 47.2% for this parameterization, or 8.6% for the Anderson parameterization. Cini et al., have pointed out that the conventional analysis of the low-energy data to obtain the S-wave scattering lengths does not satisfy crossing symmetry, and a re-analysis by Hamilton and Woolcock gives  $a_+ = -0.083$ ,  $a_- = 0.088$ , rather than the conventional values of -0.110 and 0.077. Some independent evidence in support of this conclusion was obtained by using the dispersion relations to determine  $a_+$ ,  $a_-$ , and  $f^2$  simultaneously. It is clear that a better theoretical description of the energy dependence of the total cross sections will be required before further progress can be made on this problem. (auth)

## 17306

GROUND-STATE ENERGY OF A MANY-FERMION SYSTEM. [PART] II. J. M. Luttinger (Univ. of Pennsylvania, Philadelphia) and J. C. Ward (Carnegie Inst. of Tech., Pittsburgh). *Phys. Rev.* **118**, 1417-27 (1960) June 1.

The perturbation series for the ground-state energy of a many-fermion system was investigated to arbitrary order for the "isotropic" case. This is the case of over-all spherical symmetry, both in the interaction and in the unperturbed single particle energies. It was shown that for spin one-half fermions the Brueckner-Goldstone perturbation series is valid to all orders in the perturbation. For spins greater than one-half it is in general incorrect even in the isotropic case, unless the interactions are spin independent. The discussion to arbitrary order in the interaction is carried out by means of a Feynman-like propagator formalism, which is developed in detail. (auth)

## 17307

QUANTIZED MESON FIELD IN A CLASSICAL GRAVITATIONAL FIELD. Tsutomu Imamura (Univ. of North

Carolina, Chapel Hill). Phys. Rev. **118**, 1430-4(1960) June 1.

The behavior of a quantized meson field in a classical gravitational field is examined. Physical quantities such as the expectation value for the number of created mesons are represented in terms of a formal Green's function. They are computed explicitly for the case of a special space-independent gravitational field. The inadequacy of standard iteration procedures is discussed in an Appendix. (auth)

#### 17308

ANALYTICITY PROPERTIES OF PRODUCTION AMPLITUDES. R. Ascoli and A. Minguzzi (European Organization for Nuclear Research, Geneva). Phys. Rev. **118**, 1435-8(1960) June 1.

The analytic properties of production amplitudes were studied as functions of the momentum transfer  $\Delta^2$  between one of the incoming particles and one of the outgoing particles, when the total energy and the three further parameters determining the relative motion of the three outgoing particles in the center-of-mass system are held fixed. It was found that suitable combinations of the amplitudes are analytic functions of  $\Delta^2$  regular within an ellipse in the  $\Delta^2$  plane. It is also shown that in the same domain the cross section  $\partial^2\sigma/\partial\Delta^2\partial w^2$  is an analytic and regular function of  $\Delta^2$ ,  $w^2$  being the total mass of two of the outgoing particles. The poles in  $\Delta^2$  conjectured by Chew and Low never lie inside the domain of regularity. (auth)

#### 17309

CALCULATION OF SINGLE-PARTICLE ENERGIES IN THE THEORY OF NUCLEAR MATTER. Keith A. Brueckner (Univ. of California, La Jolla); John L. Gammel (Los Alamos Scientific Lab., N. Mex.); and Joseph T. Kubis (Princeton Univ., N. J.). Phys. Rev. **118**, 1438-41(1960) June 1.

The rearrangement energy corrections to the single-particle energies were evaluated, using the procedure of Brueckner and Goldman. The shift is shown to be due largely to the second- and third-order rearrangement energy diagrams, the corrected energy at the Fermi surface now nearly agreeing with the mean binding energy. The change of the single-particle energies of virtual excitations due to rearrangement effects is also determined and shown to shift the mean binding energy by 1.5 Mev. (auth)

#### 17310

ANGULAR MOMENTUM EXPANSIONS IN RELATIVISTIC FIELD THEORY. Robert Lee Warnock (Harvard Univ., Cambridge, Mass.). Phys. Rev. **118**, 1447-54(1960) June 1.

As a step toward more general applications of angular momentum expansions in quantum field theory the expansion of the scattering matrix is examined in the case of scattering of spin 0 by spin  $1/2$  particles. The matrix is represented in terms of its eigenvalues and eigenvectors, the latter being eigenstates of total angular momentum. Using eigenstates of helicity to simplify the discussion, the eigenvectors may sometimes be obtained from the conservation laws alone. The eigenvalues are computed only to second order in a Yukawa interaction, but the results are more useful than the usual second-order matrix elements. Since angular momentum expansions lead effectively to solutions of operator equations, the expressions derived facilitate the relativistic application of Heitler's unitary approximation (with an exact solution of the equation relating the transition operator  $T$  and the Hermitian reaction operator  $K$ ) or the determinantal method of Schwinger and Baker. (auth)

#### 17311

PION PRODUCTION IN MUON-NUCLEON COLLISIONS G. von Gehlen (Università, Rome). Phys. Rev. **118**, 1455-7(1960) June 1.

A relation between the differential cross sections for certain angles and energies of inelastic electron scattering and inelastic muon scattering is given. The asymmetry of the pion production by longitudinal polarized muons has been calculated using Fubini-Nambu-Wataghin matrix elements. (auth)

#### 17312

MEASUREMENT OF THE POLARIZATION OF SYNCHROTRON RADIATION. Peter Joos (Cornell Univ., Ithaca, N. Y.). Phys. Rev. Letters **4**, 558-9(1960) June 1.

Equations are given for the amplitude of light whose plane of polarization is in the synchrotron plane and is perpendicular to it. Measurements were made for both directions of polarization of the angular intensity variation with respect to the synchrotron plane, of the light emitted during acceleration processes of peak energy 700 Mev. Experimental and theoretical intensities are shown graphically. The differences shown in the corresponding curves are due to electron oscillations, radiation band-width, and the finite slit-width, all of these effects being intrinsically more pronounced in the perpendicular component. The measurements of magnitude and angular dependence of polarization show good agreement with theory in its general shape. (B.O.G.)

#### 17313

NONADIABATIC THEORY OF THE SCATTERING OF ELECTRONS FROM HYDROGEN. A. Temkin (Goddard Space Flight Center, National Aeronautics and Space Administration, Washington, D. C.). Phys. Rev. Letters **4**, 566-8(1960) June 1.

An outline is given of a rigorous series for phase shifts in electron scattering from hydrogen. It provides a method for calculating phase shifts reliably, and the successive terms of the series can be put in a one-to-one relation with an adiabatic series which has been derived for dealing with this problem. The method is an extension of that used by Breit and by Luke et al. for calculating the energy of some excited states of 2-electron atoms and ions. (B.O.G.)

#### 17314

FORMATION OF  $\mu$ -MESONIC MOLECULES IN H-D MIXTURES. J. G. Fetkovich, T. H. Fields, G. B. Yodh, and M. Derrick (Carnegie Inst. of Tech., Pittsburgh). Phys. Rev. Letters **4**, 570-2(1960) June 1.

Experimental data are reported which allow a determination of reaction rates involved in the catalysis of nuclear reactions by  $\mu$  mesons. The chain of events believed to lead to catalysis at low deuterium concentrations is depicted. It was found that the number of regenerations per muon were nearly equal to that found by Alvarez et al. at saturation. There were found large discrepancies when the calculated and experimental values were compared. Analyses indicate that for H-(> 1%) D mixtures all absorption of  $\mu$  by protons will be from a (p-d) molecule, while for H-(< 1%) D, it is not at present possible to know the states from which muons are captured. The work presented is being extended for lesser hydrogen concentrations, which should allow more precise determinations. (B.O.G.)

#### 17315

HIGH-ENERGY BREMSSTRAHLUNG FROM A SILICON SINGLE CRYSTAL. G. Bologna, G. Diambrini, and G. P. Murtas (Comitato Nazionale per le Ricerche Nucleari, Frascati, Italy). Phys. Rev. Letters **4**, 572-5(1960) June 1.

Results are given from several measurements on bremsstrahlung from a silicon crystal. The silicon crystal is a half-circular plate 15 mm in diameter and  $2.7 \times 10^{-3}$  radiation lengths in thickness; it is cut perpendicular to the axis [111] within  $\pm 4$  mrad, as determined by a Laue x-ray back-reflection method. The crystal could be rotated about a horizontal and a vertical axis; the precision of angle measurements is  $\pm 0.5$  mrad. Intensities of bremsstrahlung produced in a Si single crystal ( $T = 293^\circ\text{K}$ ) are given as a function of  $\theta$ , the angle between the 1-Bev electron beam and the crystal axis, and as a function of the fractional energy of the photon with respect to the electron energy. A central minimum is shown to exist in the plot of the bremsstrahlung intensity and  $\theta$ , whereas this condition was not shown to exist in previous experiments. It is believed that this is due to insufficient angular resolution with respect to the low-energy detected photons. (B.O.G.)

17316

## P-WAVE RESONANCE IN PION-PION SCATTERING.

Benjamin W. Lee and Michael T. Vaughn (Univ. of Pennsylvania, Philadelphia). Phys. Rev. Letters **4**, 578-80 (1960) June 1.

It has been suggested that there is more than one solution to the integral equations for  $\pi\pi$  partial wave scattering. The possible source of such a multiplicity of solutions is pointed out from the viewpoint of conventional Lagrangian field theory, and an examination is made of the significance of the fact that the p-wave phase shift remains small throughout the physically acceptable range of the  $\pi\pi$  coupling constant in the "s-wave dominant solution." It is crucial for the discussion to realize that the form of the double dispersion representation is uniquely determined by the masses of participating particles and the selection rules. Assuming the existence of a vector boson of isotopic spin one and insisting that the renormalized mass of the postulated particle be larger than twice the pion mass, then the particle will become unstable and the selection rules of the theory have not changed from those of conventional pseudoscalar meson theory. These assumptions are extended to predict p-wave resonance in  $\pi\pi$  scattering. (B.O.G.)

17317

PRODUCTION OF NUCLEON ISOBARS IN PROTON-PROTON COLLISIONS. G. B. Chadwick, G. B. Collins, and C. E. Swartz (Brookhaven National Lab., Upton, N. Y.); A. Roberts (Univ. of Rochester, N. Y.); S. De-Benedetti and N. C. Hien (Carnegie Inst. of Tech., Pittsburgh); and P. J. Duke (National Inst. for Research in Nuclear Science, Harwell, Eng.). Phys. Rev. Letters **4**, 611-13 (1960) June 15.

The energy spectra of inelastically scattered protons from p-p collisions at 1.04 to 2.04 Bev were studied in order to investigate the validity of the isobar model of pion production. The results, plotted for energies of 1.20, 1.60, and 2.04 Bev, agree well with the curve expected for single meson production, which indicates that single meson production predominates over that of double mesons at small angles. There is no evidence for resonances at 1.52 and 1.87 Bev which were suggested by previous work on pion photoproduction and  $\pi$ -N scattering. (D.L.C.)

17318

NEUTRINOS EMITTED IN  $\beta$  DECAY AND  $\mu$  CAPTURE. S. P. Rosen (Midwestern Universities Research Assn., Madison, Wis.). Phys. Rev. Letters **4**, 613-15 (1960) June 15.

The helicities of the neutrinos produced in  $\mu^-$  capture ( $\mu^- + p \rightarrow n + \nu$ ) and in nucleus decay ( $[A, Z] \rightarrow [A, Z-1] +$

$\beta^+ + \nu$ ) were examined by assuming that these helicities are opposite to each other. This assumption leads to the consequences of the rejection of (1) the universality of vector-axial (V-A) coupling in weak interactions, (2) the two-component neutrino, and (3) the present form of the intermediate vector boson theory. Whether the assumption is valid or not depends on the helicity of the muon emitted in  $(\pi\mu)$  decay. (D.L.C.)

17319

EFFECT OF THE PION-PION RESONANCE ON  $K^-$ -p SCATTERING. Fabio Ferrari, Graham Frye, and Modesto Pusterla (Univ. of California, Berkeley). Phys. Rev. Letters **4**, 615-18 (1960) June 15.

The assumption that, in the  $K^-$ -p interaction,  $k \cot \delta$  is constant and equal to the reciprocal scattering length is examined on the basis of the Chew-Mandelstam program. It is concluded that the  $\pi\pi$  exchange, which determines the long range tail of the K-N interaction, gives a substantial energy dependence to  $k \cot \delta$ . (D.L.C.)

17320

THEORY OF  $\Sigma$ -HYPERON DECAYS. Saul Barshay (Brandeis Univ., Waltham, Mass.) and Melvin Schwartz (Columbia Univ., New York). Phys. Rev. Letters **4**, 618-20 (1960) June 15.

A theory of hyperon ( $\Sigma$ ) decay is given in which the  $\Sigma$  is considered as a bound state of a  $\Lambda^0$  and a pion. In this way, some observed features of  $\Sigma$  decay can be explained in terms of the observed properties of  $\Lambda^0$  decay. (D.L.C.)

17321

ELECTROMAGNETIC CORRECTIONS TO THE DECAYS OF THE MUON,  $O^{14}$ , AND THE NEUTRON. Loyal Durand, III, Leon F. Landovitz, and Robert B. Marr (Brookhaven National Lab., Upton, N. Y.). Phys. Rev. Letters **4**, 620-4 (1960) June 15.

The radiative and other corrections to the vector coupling constants were calculated using dispersion techniques for  $\text{Al}^{28}$ ,  $\text{Cl}^{34}$ ,  $O^{14}$ , muon, and neutron decays. If the vector coupling constants for the muon and  $O^{14}$  decays are taken to be the same, a muon lifetime of  $2.23 \pm 0.05 \times 10^{-6}$  sec is obtained, in good agreement with the experimental value of  $2.21 \pm 0.005 \times 10^{-6}$  sec. (D.L.C.)

17322

SOME APPLICATIONS OF THE GENERALIZED UNITARITY RELATION. R. E. Cutkosky (Carnegie Inst. of Tech., Pittsburgh). Phys. Rev. Letters **4**, 624-6 (1960) June 15.

The generalized unitarity and dispersion relations are shown by examples to greatly increase the usefulness of analytic continuation (from perturbation theory) in calculation of the discontinuity of a threshold graph. Two examples considered are the  $\pi + \pi \rightarrow \Sigma + \Sigma$  reaction and the deuteron. (D.L.C.)

17323

THE STRUCTURE OF A NON-RELATIVISTIC S-MATRIX. K. J. Le Couteur (Atomic Energy Research Establishment, Harwell, Berks, Eng.). Proc. Roy. Soc. (London) **A256**, 115-27 (1960) May 31.

The S-matrix for the non-relativistic scattering of a particle by a target possessing discrete excited states is considered. Assuming the S-matrix to be an analytic function of the energy, the unitarity and reversibility conditions are extended into the complex plane, and it is shown how all the elements of the S-matrix can be constructed from a single function of the momenta of the particle in the various channels, which has zeros at the poles of S. For the two channel problem the S-matrix is

constructed explicitly from the positions of its poles in the complex plane together with conditions at  $\infty$ , and necessary conditions on the number and positions of the poles are formulated. (auth)

17324

A SIMPLE PROOF OF DISPERSIVE RELATIONS. T. S. Chang (Inst. of Mathematics, Academy of Sciences, Peking). Sci. Sinica (Peking) 9, 459-65(1960) Apr. (In English)

A proof for dispersive relations is derived by expanding the causal amplitude with respect to the intermediate states and considering the analyticity of the energy denominator and numerator separately. Meson scattering by nucleons is used as an example. Analytic extension of phase shifts in potential scattering is also considered. (D.L.C.)

17325

REMARKS ON CHEW-LOW EQUATIONS. T. S. Chang (Inst. of Mathematics, Academy of Sciences, Peking). Sci. Sinica (Peking) 9, 466-74(1960) Apr. (In English)

The Chew-Low formalism is compared with the conventional formal theory of scattering and their wave functions are found to be identical except for a constant representing a physical nucleon and a bare nucleon. Conditions are derived for the existence of solutions to the Chew-Low equations. (D.L.C.)

17326

THE FIRST ORDER WAVE EQUATION FOR A FREE NUCLEON. Kh. Yiglane. Trudy Inst. Fiz. i Astron. Akad. Nauk Eston. S.S.R. No. 9, 43-56(1959). (In Russian)

A free nucleon first order wave equation is derived from two Klein-Gordon equations for the free proton and the free neutron, respectively where the constant  $k_0$  and  $a$  are chosen so as to give the proton and neutron masses entering into the equations. The simultaneous linearization of these two equations yields a first order equation, the operators  $\Gamma'$ ,  $T_3$ , and  $I$  satisfying the commutation relations. The analysis in section 3 shows that there is only one irreducible representation of  $\Gamma'$ ,  $T_3$ , and  $I$ , namely, the representation by  $8 \times 8$  matrices. The state function is determined by the system, where  $H$  denotes the Hamiltonian,  $S$  the operator of the spin projection, and  $T_3$  that of the third isospin component. It turns out that in the non-relativistic approximation the components of the nucleon state function are characterized by three quantum numbers; the spin projection, the energy sign, and the third isospin component  $t_3$ . The results are tabulated. Two linearly independent current vectors follow from the state equation. One of them describes a special nucleonic current, and the other the electric current. The nucleon's electric charge operator is given. Eigenvalues of this operator in the neutron states are equal to zero, and in the proton states equal to  $e$ . (auth)

17327

WAVE EQUATIONS FOR MULTIPLETS OF FREE FERMIONS. Kh. Yiglane. Trudy Inst. Fiz. i Astron. Akad. Nauk Eston. S.S.R. No. 9, 57-70(1959). (In Russian)

A wave equation is derived for a free nucleon and  $\Xi$ -hyperon. It proves that the kind of the particle is generally characterized by two quantum numbers—by the third isospin component  $t_3$  and by the third isomomentum component  $\nu_3$ . The nucleon and  $\Xi$ -hyperon form a doublet with respect to  $t_3$  as  $\nu_3$ . An equation is derived for the free  $\Sigma$ -hyperon. It forms a triplet with respect to  $t_3$ , but a singlet with respect to  $\nu_3$ . An equation is derived for  $\Lambda$ -hyperons.  $\Lambda$ -particles form a singlet with respect to  $t_3$ ,

but as to  $\nu_3$ —a triplet. The charged  $\Lambda$ -particles are identified with  $Z^+$  and  $\Omega^-$ -hyperons predicted by Gell-Mann. All baryons are characterized by the quantum numbers  $t_3$  and  $\nu_3$ . There are found three linearly independent expressions for the charge operators of baryons. The baryonic charge operator and the electric charge operator are given. For the specification of the third charge operator the sufficient facts are lacking. Notions of isospin and isomomentum are extended to leptons. The quantum numbers  $t_3$  and  $\nu_3$  characterizing leptons are given. The equation describing the electron and the neutrino is given with specified constants. The equation for the  $\mu$ -meson is given with specified constants. In this case the neutral  $\mu$ -meson has the zero rest-mass. In spite of the complexity of the system of quantum numbers  $t_3$  and  $\nu_3$ , there exist actually only 3 kinds of respective particles—the electron,  $\mu$ -meson, and the neutral particle with zero mass. The last may be in states with  $t_3 = 0, \pm \frac{1}{2}$  and  $\nu_3 = 0, \pm \frac{1}{2}$ . (auth)

17328

WAVE EQUATIONS FOR MULTIPLETS OF FREE BOSONS. Kh. Yiglane. Trudy Inst. Fiz. i Astron. Akad. Nauk Eston. S.S.R. No. 9, 71-83(1959). (In Russian)

An equation was derived which leads to the same second order equation as the Proca-Kemmer-Duffin's equation. This facilitates the construction of the theory for multiplets of free bosons quite analogically to the theory for multiplets of free fermions. The equations for free  $K$ -mesons and free  $\pi$ -mesons are derived. Quantum numbers  $t_3$  and  $\nu_3$  characterizing the kind of a meson are given. The equations for multiplets of mesons are invariant under all transformations of the full Lorentz group. It means, that to the case of bosons the notion of the common parity applies. For comparison it may be mentioned that the equations for fermions are invariant only under simultaneous inversions of the coordinate axes in the common and iso-space. To fermions the generalized notion of parity applies, that in the case of leptons coincides with combined parity of Lee and Yang, and Landau. The analysis of experimental results indicates that in the cases of electromagnetic and strong interactions  $t_3$  and  $\nu_3$  represent constant quantities. In the case of weak interaction only the sum  $t_3 + \nu_3$  will be constant, while  $t_3$  and  $\nu_3$  separately vary by  $\pm \frac{1}{2}$ . The only invariable charge in any process, attributed to elementary particles, is the electric charge. Baryons possess besides the electric charge, the strong interaction charge, whose constancy represents the conservation law of baryons. Because there is no conserved charge of weak interaction, it seems that the weak interaction is to be reckoned in equations for free particles. (auth)

17329

PHOTOPRODUCTION OF CHARGED  $\pi$ -MESONS NEAR THE THRESHOLD. M. I. Adamovich, E. G. Gorzhevskaya, V. G. Larionova, V. M. Popova, S. P. Kharlamov, and F. R. Yagudina. Zhur. Ekspl. i Teoret. Fiz. 38, 1078-83(1960) Apr. (In Russian)

The differential cross sections for photoproduction of positive  $\pi$ -mesons on hydrogen were measured in the energy range 153 to 175 Mev. Total cross sections for photoproduction of negative  $\pi$ -mesons on deuterium are presented. The experimentally derived squares of the matrix elements for  $\pi^+$ - and  $\pi^-$ -meson photoproduction of free nucleons  $|K_p|^2$  and  $|K_n|^2$  are compared with the theoretical values. The quantity  $|K_n|^2$  is compared with the Panofsky ratio and with the meson-nucleon interaction S-phase shifts. The value of the ratio was obtained in the photon energy range from 153 to 175 Mev. (auth)

## 17330

ELASTIC SCATTERING OF 240 TO 330 Mev  $\pi^-$ -MESONS ON HYDROGEN. V. G. Zinov and S. M. Korenchenko. *Zhur. Eksptl'. i Teoret. Fiz.* 38, 1099-1105(1960) Apr. (In Russian)

Results of measurement of the differential cross sections for elastic scattering of 240, 270, 307, and 333 Mev  $\pi^-$ -mesons on hydrogen are presented. (auth)

## 17331

POLARIZATION EFFECTS IN THE SCATTERING OF ELECTRONS ON DEUTERONS. G. V. Frolov. *Zhur. Eksptl'. i Teoret. Fiz.* 38, 1148-52(1960) Apr. (In Russian)

The differential cross section and change in electron polarization which occurs when polarized deuterons are disintegrated by polarized electrons are calculated with account of electromagnetic nucleon form factors. An expression is derived for the polarization of recoil deuterons in elastic scattering of polarized electrons on unpolarized deuterons. (auth)

## 17332

RADIATIVE CORRECTIONS TO COULOMB SCATTERING WITH ACCOUNT OF THE MEDIUM. M. L. Ter-Mikaelyan. *Zhur. Eksptl'. i Teoret. Fiz.* 38, 1167-9(1960) Apr. (In Russian)

Radiative corrections to electron scattering are treated with account of the "density effect." If the condition for  $\omega_{\min}$  is fulfilled, corrections due to the medium become important and are given by the formula for  $d\sigma$ . (auth)

## 17333

POLARIZATION OF DEUTERONS ELASTICALLY SCATTERED ON ZERO SPIN NUCLEI. G. M. Budynskii. *Zhur. Eksptl'. i Teoret. Fiz.* 38, 1170-5(1960) Apr. (In Russian)

The most general form of the transition matrix is presented. The dependence of the transition matrix parameters on experimentally observed quantities is established. The general and explicit expressions for the double scattering cross section and vector and tensor polarization are derived in which account is made of mixing of different waves. Phase shifts, and hence a description of scattering, can be obtained by choosing a special form of the potential (such as that employed in the optical model). Calculations performed in the Born approximation are compared with the experimental results. (auth)

## 17334

COHERENT RADIATION OF ELECTRONS IN A SYNCHROTRON. [PART] III. M. S. Rabinovich and L. V. Logansen. *Zhur. Eksptl'. i Teoret. Fiz.* 38, 1183-7(1960) Apr. (In Russian)

Electromagnetic interaction of electrons in a synchrotron is considered with account of the shielding action of the chamber walls on a bunch of arbitrary shape. The effect of these forces on the electron phase motion and size of the bunch is estimated. (auth)

## 17335

ANALOGY BETWEEN WEAK AND ELECTROMAGNETIC INTERACTIONS. E. M. Lipmanov. *Zhur. Eksptl'. i Teoret. Fiz.* 38, 1233-6(1960) Apr. (In Russian)

Weak and electromagnetic interactions are treated in such a manner that the electric current and charged currents in weak interactions can be derived from a single symmetric expression, which includes the operators  $\frac{1}{2} + \tau$  and  $1 + \gamma_5$ , after imposing the requirements of conservation of electric, lepton, and baryon charges and vanishing of the photon mass. A certain "chirality" is ascribed to half-

integral spin particles which is conserved in weak interactions. "Bare" Fermi particle doublets in weak and electromagnetic interactions are classified with respect to their electric charge, lepton or baryon charge, and chirality values. (auth)

## 17336

STRUCTURE OF THE S-MATRIX IN THE THEORY OF ELASTIC AND INELASTIC SCATTERING OF NONRELATIVISTIC PARTICLES. Yu. V. Tsekhmistrenko. *Zhur. Eksptl'. i Teoret. Fiz.* 38, 1237-44(1960) Apr. (In Russian)

Integral relations for components of the S-matrix describing a two-channel nuclear reaction (one of the channels corresponds to elastic scattering of a nonrelativistic particle and the other to inelastic scattering with excitation of the nucleus) are derived from general principles of causality, unitarity, and symmetry. The analytical properties of some S-matrix components are also established. For sake of simplification the treatment is confined to the case of spherically symmetrical scattering. In agreement with the results of Wigner and Baz the elastic scattering excitation function has a break at the threshold of the inelastic process. The excitation function for the inelastic process near the threshold has been found in general form. (auth)

## 17337

LEPTON DECAYS OF HYPERONS INVOLVING THE EMISSION OF  $\pi$ -MESONS. I. S. Tsukerman. *Zhur. Eksptl'. i Teoret. Fiz.* 38, 1285-7(1960) Apr. (In Russian)

The total probabilities for lepton decays of hyperons with emission of a  $\pi$ -meson,  $Y \rightarrow N(Y') + l + \nu + \pi$  ( $l$  denotes an electron or  $\mu$ -meson) are estimated in the case of the simplest matrix element of the universal  $V - A$ -interaction for one of the possible diagrams of perturbation theory. (auth)

## 17338

ON SOME GENERAL PROPERTIES OF THE PHOTON PROPAGATION FUNCTION IN QUANTUM ELECTRODYNAMICS. A. A. Ansel'm. *Zhur. Eksptl'. i Teoret. Fiz.* 38, 1288-96(1960) Apr. (In Russian)

By comparing the spectral expansion of the photon Green's function with the renormalizability property, the behavior of the D-function is investigated for very large energies,  $e^2 = 1/\beta_1$ , and for very large charges but not very high energies. With an accuracy to within a numerical parameter the dependence of the D-function on charge could be established in the first case and on the energy in the second. (auth)

## 17339

THE SCATTERING AND DIFFRACTION OF WAVES.

Ronald W. P. King and Tai Tsun Wu. Harvard Monographs in Applied Science. Number 7. Cambridge, Mass., Harvard University Press, 1959. 232p.

A summary is given of the fundamental research in the general field of electromagnetic radiation. It includes those aspects of diffraction and scattering that properly fall under the broad heading of reflections from surfaces of complex shape. An effort is made to provide an integrated picture of research and the problems of research in that area. This, it is hoped, provides a useful survey of important phases of the theoretical and experimental problems in the broad field as a whole, and an introduction to the difficulties involved in their solution. (B.O.G.)

## 17340

AIR FLUORESCENCE EXCITED BY GAMMA RAYS AND X-RAYS. D. R. Westervelt, E. W. Bennett, and A. Sku-

manich (Los Alamos Scientific Lab., N. Mex.). p.225-9 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Air fluorescence excited by  $\gamma$  and x rays from nuclear explosions was observed and analyzed to obtain values for fluorescence efficiency and information regarding excitation. Emission is principally in the  $N_2$  Second Positive and  $N_2^+$  First Negative systems; for sea level explosions the efficiency in the  $\lambda 4060$  (0.3) band of  $N_2$  (2P) was measured to be  $7 \times 10^{-6}$ , while a "total" efficiency of  $2 \times 10^{-4}$  was obtained for emission within the spectral range defined by S-11 photocathode sensitivity. A pressure dependence of efficiency found by Grin in laboratory measurements was used to predict a brightness and time history for fluorescence excited at altitudes near 25 km by gamma rays from a high altitude explosion. The results were in agreement with observations. A value  $3 \times 10^{-5}$  for efficiency at still higher altitudes in the  $\lambda 5228$  (0.3) band of  $N_2^+$  (1N) was calculated from observations of x ray induced fluorescence in the region 45-82 km. Intensities of the lower  $v'$  levels in the  $(0, v')$  progression of  $N_2^+$  (1N) were drastically modified by absorption, but it is possible to arrive at a lower limit for the efficiency of  $\lambda 3914$  (0.0) emission from known intensity ratios in the series. This limit is  $5 \times 10^{-3}$  for pressures below 1 mm Hg. It is found that  $N_2$  (2P) excitation at very high altitudes is somewhat greater relative to  $N_2^+$  (1N) than at sea level; from this observation it is tentatively concluded that indirect excitation of  $N_2$  (2P) at sea level is not significant. (auth)

#### 17341

SPECTRAL STUDY OF THE LUMINESCENCE FROM EXCITATION OF RARE GASES BY ALPHA RAYS. Lydie Koch (Centre d'Etudes Nucléaires, Saclay, France). p.230-5 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In French)

Excited levels and energy exchange mechanisms from collisions between nuclear particles and rare gas atoms are investigated to analyze the gaseous scintillation phenomenon. Spectrum analysis of light emission due to  $\alpha$  rays moving in the gas indicates obviously energy exchange particularly with mercury and nitrogen impurities atoms. (auth)

#### 17342

INFLUENCE OF THE ELECTRON VELOCITY DISTRIBUTION UPON THE SPACE CHARGE WAVE PROPERTIES OF ELECTRON BEAMS. O. E. H. Rydbeck and H. Wilhelmsson (Chalmers Tekniska Högskola, Göteborg). p.653-6 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The velocity distribution function considered is a pulse of certain width and constant amplitude. It is shown that the space charge wave propagation properties of an electron beam practically vanish when the relative velocity-spread becomes greater than the ratio between plasma and signal frequencies. The velocity distribution is found to decrease the gain and the gain-velocity bandwidth of modern space charge amplifiers. (auth)

#### 17343

SPACE-CHARGE WAVES IN AN ELECTRON BEAM OF

VARIABLE RADIAL DENSITY. O. E. H. Rydbeck and M. Fischer (Chalmers Tekniska Högskola, Göteborg). p.657-64 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In German)

The space charge wave properties of electron beams are quite well known for streams of constant current density. However, if the current density varies across the drift direction, as is often the practical case, the space charge wave lengths are very difficult to determine. Space charge wave properties of electron beams with current densities varying as  $\rho_0/\rho$  or  $\exp(-\rho^2/\rho_0^2)$  where  $\rho$  is the transverse distance from the axis of the beam, were studied in some detail by analysis of the proper wave functions. The possible space charge wave modes and the corresponding plasma frequency reduction factors are discussed and compared with what is known for the constant density beams. (auth)

## Nuclear Properties and Reactions

#### 17344 AWRE-O-2/60

United Kingdom Atomic Energy Authority. Weapons Group. Atomic Weapons Research Establishment, Aldermaston, Berks, England.

AVERAGE CROSS-SECTIONS FOR FISSION SPECTRUM NEUTRONS. R. Hinves and K. Parker. Apr. 1960. 14p.

Average cross-sections for fission spectrum neutrons were calculated for a number of nuclides and compared to experimental measurements. (C.J.G.)

#### 17345 CF-60-4-11

Oak Ridge National Lab., Tenn.

DETERMINATION OF  $\bar{\eta}$  BY COMPARISON OF  $\bar{\eta}\bar{\sigma}_a$  FOR  $U^{233}$  AND  $Pu^{239}$  WITH  $\bar{\eta}\bar{\sigma}_a$  FOR  $U^{235}$  IN A FLUX TRAP CRITICAL ASSEMBLY. R. Gwin and D. W. Magnuson. Apr. 6. 1960. 16p. Contract [W-7405-eng-26]. OTS.

The values of  $\bar{\eta}$  for  $U^{233}$  and  $\bar{\eta}$  for  $Pu^{239}$  were determined by a reactivity coefficient measurement. An aqueous solution of the isotope was introduced axially into a critical cylindrical annular flux trap reactor, and the resulting reactivity change measured by period determinations. From these data the ratio  $\bar{\eta}\bar{\sigma}_{ax}/\bar{\eta}\bar{\sigma}_a(U^{235})$  was obtained. Using recently measured values of  $\bar{\sigma}_a(U^{235})$  and  $\bar{\eta}$  for  $U^{235}$  in this ratio gives the thermal value of  $2.308 \pm 0.040$  for  $\bar{\eta}$  of  $U^{233}$  and  $1.995 \pm 0.053$  for  $\bar{\eta}$  of  $Pu^{239}$ . Correction to a neutron velocity of 2200 m/sec by using the appropriate g-factor gives a value of  $2.308 \pm 0.040$  for  $\eta$  of  $U^{233}$  and  $2.044 \pm 0.054$  for  $\eta$  of  $Pu^{239}$ . (auth)

#### 17346 CNC-29

Italy. Comitato Nazionale per le Ricerche Nucleari, Rome and Italy. Istituto Nazionale di Fisica Nucleare. Scuola di Fisica Nucleare Applicata, Rome.

SULLA FLUORESCENZA DI RISONANZA NUCLEARE. (On the Nuclear Resonance Fluorescence). D. Prosperi, M. C. Ramorino, and S. Scuti. Mar. 1960. 138p.

Experimental works based on nuclear resonance fluorescence (N.R.F.) are reviewed. Determinations of mean lives and nuclear level widths are described; further the theoretical interpretation of the more important results is supplied. Experimental results performed with N.R.F. methods are compared with those obtained with other techniques (electronics, Doppler broadening, etc.) showing generally a good agreement. The application of nuclear resonance fluorescence to the study of weak interactions and to tests on general relativity theory is briefly described in the Appendix. (auth)

## 17347 LA-1863

Los Alamos Scientific Lab., N. Mex.

EMISSION PROBABILITIES OF PROMPT NEUTRONS FROM SPONTANEOUS AND NEUTRON-INDUCED FISSION. R. B. Leachman. Dec. 1954. Decl. May 5, 1960. 41p. Contract W-7405-Eng-36. OTS.

A method is developed for using the relatively easily measured fission parameters, together with the mass equation of fission and the evaporation model of the nucleus, to determine the emission probabilities of the fission neutrons. The distribution of the kinetic energies of the fragment pairs enters into these calculations in a sensitive manner. Neutron emission probabilities are computed for the fission of the compound nuclei  $U^{234}$ ,  $U^{238}$ , and  $Pu^{240}$ , for which cases reasonably adequate data on the fragment pair energies are available. Although the corresponding data for the fission of the compound nuclei  $Th^{233}$ ,  $U^{238}$ , and  $U^{239}$  are considerably poorer, neutron emission probabilities are also computed. The calculated results from this method are in good agreement with direct measurements of fission neutrons. (auth)

## 17348 TID-3901

Brookhaven National Lab., Upton, N. Y.

HIGH ENERGY NUCLEAR REACTIONS. A Literature Search. Jerome Hudis. Mar. 1960. 42p. OTS.

The literature was searched for references pertaining to high-energy reactions of interest to nuclear chemists. The criteria used in the selection of the references were: (a) energy of incident particle  $> 50$  Mev; (b) mass of target  $\geq 9$ ; (c) products with  $Z > 2$ , but including  $H^3$ ,  $He^3$ , and  $He^6$  yields; and (d) no heavy ion induced reactions. Nuclear Science Abstracts was the main source of references and wherever possible the complete abstract was retained. Some of these references were used to compile a table of experimental results of high-energy nuclear reactions which is included in a paper by Miller and Hudis in the Annual Review of Nuclear Science for 1959. These references are arranged by senior author. 350 references. (auth)

## 17349 AEC-tr-3720

Heidelberg, Germany. Universität. Institut für Theoretische Physik.

A GENERAL FORMULATION OF THE SURFACE REACTIONS WITH THE USE OF ANGLE DISTRIBUTION IN STRIPPING REACTIONS. H. A. Weidenmüller. Translation of "Eine Allgemeine Formulierung der Theorie der Oberflächenreaktionen mit Anwendung auf die Winkelverteilung bei Strippingreaktionen." 32p. JCL.

Following the formal theory of nuclear reaction, a derivative for the amplitude of the  $(d,p)$  and  $(d,n)$  reaction is given with the use of an equation by Thomas as an example of surface reaction in which the many-body problem and the Pauli principle are taken into consideration exactly. The neglected factors which enter into the final formula are discussed. As in the case of Thomas, the amplitude is a sum from two terms in good approximation, one of which is the usual matrix element for the stripping reaction—i.e., the "surface term"—while the other represents exactly the contribution of the "internal region" which is given by the formal theory of nuclear reaction. The formula is used for the interpretation of angle distributions in stripping reactions. (auth)

## 17350 NP-tr-440

FISSION NEUTRONS AND CAPTURE NEUTRONS. G. Q. Translated by I. T. Saunders (U.K.A.E.A. Atomic Energy Research Establishment) from Atompraxis 3, 258-9 (1957). 7p. JCL.

The mean number of secondary neutrons  $\nu_{eff}$  formed per capture in  $U^{233}$ ,  $U^{235}$ , and  $Pu^{239}$  was measured from thermal energies to 900 kev. For  $U^{233}$ ,  $\nu_{eff}$  remained unchanged up to energies of the order of 100 ev. For  $U^{235}$   $\nu$  remained unchanged during the transition into the 0.15 to 0.5 ev range, but was reduced by 18% during the transition from 8 to 130 ev. For  $Pu^{239}$ , the  $\nu$  was reduced by 12% during the passage from thermal into the energy range of 0.15 to 0.5 ev, after which it remains constant. The results on  $U^{235}$  and  $Pu^{239}$  were in reasonable agreement with those of Kane, et al. (C.J.G.)

## 17351

ON AN APPLICATION OF THE STATISTICAL VARIATIONAL PRINCIPLE TO THE THEORY OF THE ATOMIC NUCLEUS. V. G. Solov'ev and T. Gyn (Joint Inst. for Nuclear Research, Dubna, USSR). Acta Phys. Acad. Sci. Hung. 11, 277-83 (1960). (In Russian)

The statistical variational principle is used for investigating the superfluid state of the finite nucleus at non-zero temperature. The temperature of the phase transition of a nucleus from the superfluid to the normal state is obtained; behavior of thermodynamical quantities at temperatures close to zero as well as close to the critical temperature is considered. (auth)

## 17352

PRECISION MEASUREMENTS OF GAMMA ENERGIES AND INTENSITIES BY CRYSTAL DIFFRACTION. Pär Bergvall (Univ. of Uppsala). Arkiv Fysik 17, 125-47 (1960). (In English)

Precision measurements of gamma energies from 100 to 600 kev in the decays of  $ThB$ ,  $Au^{196}$ ,  $Sm^{153}$ , and  $Ir^{192}$  are reported with the following results for three strong standard reference lines:  $ThB$ ,  $238.599 \pm 0.022$  kev;  $Au^{196}$ ,  $411.770 \pm 0.033$  kev; and  $Sm^{153}$ ,  $103.175 \pm 0.004$  kev. An efficiency calibration of the curved crystal (quartz (310), 1.5 mm thick, 2 m radius), is found to give the following energy dependence of the reflection coefficient:  $\Gamma \sim E^{-1.99 \pm 0.10}$ . The spectrometer efficiency is further discussed and relative intensities of some strong lines in  $Ir^{192}$  are given. (auth)

## 17353

THE HIGH-FREQUENCY DEFLECTION METHOD FOR MEASURING SHORT HALF-LIVES. PART I. PRINCIPLE AND SOME MEASUREMENTS. B. Johansson and T. Alväger (Nobel Inst. of Physics, Stockholm). Arkiv Fysik 17, 163-76 (1960). (In English)

Some investigations of the high-frequency deflection method for measuring short half lives were made. The method is shown to be useful for measuring the half lives of moderately converted  $\gamma$  transitions below 1 Mev fed by converted  $\gamma$  transitions,  $\beta$  radiation, or possibly also  $\alpha$  radiation. Half lives in the range  $10^{-10}$  to  $10^{-13}$  sec should be measurable from the slope of the resolution curve. With a frequency of 146 mc, a resolving time of  $3 \times 10^{-10}$  sec was obtained for the test arrangement for 300 kev conversion electrons. The slope of the resolution curve corresponds to a half life of  $3 \times 10^{-11}$  sec. Some preliminary measurements were performed: For the 279 kev level in  $Tl^{203}$ ;  $T_{1/2} = 2.2 \pm 0.3 \times 10^{-10}$  sec. For the 313 kev level in  $U^{233}$ ;  $T_{1/2} = 2.0 \pm 0.3 \times 10^{-10}$  sec. For the 2385 kev level in  $Pb^{208}$ ;  $T_{1/2} \leq 3 \times 10^{-11}$  sec. For the 239 kev level in  $Bi^{212}$ ;  $T_{1/2} \leq 8 \times 10^{-11}$  sec. (auth)

## 17354

DERIVATION OF THE MEAN NUMBER OF SECONDARY NEUTRONS PER FISSION FROM THE MASS DISTRIBUTION OF THE PRODUCTS. Yu. A. Zysin, A. A. Lbov, and L. I. Sel'chenkov. Atomnaya Energ. 8, 409-12 (1960) May. (In Russian)

An evaluation is made of the order of error in the method for calculating the mean number of secondary neutrons  $\bar{\nu}$  by fission product mass distribution curves. It is shown that in cases where these curves are well studied the  $\bar{\nu}$  can be determined with satisfactory accuracy. Calculations are made of  $\bar{\nu}$  for  $\text{Th}^{232}$ ,  $\text{U}^{235}$ ,  $\text{U}^{236}$ ,  $\text{U}^{238}$ ,  $\text{Pu}^{239}$ ,  $\text{Am}^{241}$ , and  $\text{Cf}^{252}$ . The obtained data are analyzed and correlated with data obtained by other methods. Partial magnitudes  $\bar{\nu}_m$  were derived for  $\text{U}^{233}$  and  $\text{U}^{235}$  fission by thermal neutrons. (tr-auth)

## 17355

THE MEAN NUMBERS OF PROMPT NEUTRONS PRODUCED IN PHOTOFISSION OF  $\text{Th}^{232}$  AND  $\text{U}^{238}$  BY THE  $\gamma$ -RAYS FROM THE  $\text{F}^{19}(\text{p},\alpha\gamma)\text{O}^{16}$  REACTION. L. I. Prokhorova and G. N. Smirenkin. Atomnaya Energ. **8**, 457-9(1960) May. (In Russian)

The mean number of prompt neutrons  $\bar{\nu}$  emitted per  $\text{U}^{238}$  and  $\text{Th}^{232}$  photofission by  $\gamma$  rays from the  $\text{F}^{19}(\text{p},\alpha\gamma)\text{O}^{16}$  reaction produced in  $\text{CaF}_2$  bombardment by 2.6 Mev protons was measured. The  $\gamma$  spectrum has three lines of 6.13, 6.9, and 7.1 Mev. The admixture of  $\gamma$  rays with  $\sim 12$  Mev from  $\text{F}^{19}(\text{p},\gamma)\text{Ne}^{20}$  was less than 0.2%. The mean  $\gamma$  energy in  $\text{U}^{238}$  and  $\text{Th}^{232}$  fissions was  $\sim 6.7$  Mev. Measurements were made with a Van de Graaff electrostatic generator. The number of neutrons in  $\text{U}^{238}$  and  $\text{Th}^{232}$  fission was correlated with the corresponding number for spontaneous fission of  $\text{Pu}^{240}$ , determined with an order of accuracy of 2% to be  $\bar{\nu}_0 = 2.26 \pm 0.05$ . After experimental corrections the ratio  $\nu/\nu_0$  for the uranium was  $1.86 \pm 0.09$  and for thorium  $1.42 \pm 0.09$ . Using these values, the  $\nu_u = 4.2 \pm 0.2$  and  $\nu_{Th} = 3.2 \pm 0.2$ . The obtained data show that a larger fragment deformation is found in  $\text{U}^{238}$  and  $\text{Th}^{232}$  photofission than in neutron fission. (R.V.J.)

## 17356

THE THERMAL NEUTRON CAPTURE CROSS SECTION AND RESONANCE CAPTURE INTEGRAL OF PROTACTINIUM-233. T. A. Eastwood and R. D. Werner (Atomic Energy of Canada Ltd., Chalk River, Ont.). Can. J. Phys. **38**, 751-69(1960) June.

The thermal neutron capture cross section and resonance capture integral of  $\text{Pa}^{233}$  to form the 1.2-minute and 6.7-hour isomeric states of  $\text{Pa}^{234}$  were measured using activation methods. The results are tabulated. Irradiations made with different thicknesses of cadmium cover show the absence of a major resonance for the formation of the 6.7-hour state in the region of the cadmium cutoff. The results are compared with earlier values and some reasons for discrepancies were studied experimentally. (auth)

## 17357

SOME RECENT DETERMINATIONS OF ATOMIC MASSES IN THE STRONTIUM-ZIRCONIUM REGION. N. R. Isenor, R. C. Barber, and H. E. Duckworth (McMaster Univ., Hamilton, Ont.). Can. J. Phys. **38**, 819-23(1960) June.

A large double-focusing mass spectrometer was used to obtain new values for the masses of  $\text{Sr}^{86}$ ,  $\text{Si}^{88}$ , and  $\text{Zr}^{90}$ . Mass differences calculated from these values are found to be in better agreement with nuclear transmutation information than were previous mass spectroscopically derived values. (auth)

## 17358

GAMMA RADIATION IN THE DECAY OF  $\text{Ag}^{113}$ . A. Kjelberg, H. Taniguchi, and L. Yaffe (McGill Univ., Montreal). Can. J. Phys. **38**, 866-8(1960) June.

Recent work has indicated that the decay of  $\text{Ag}^{113}$  is

more complex than was shown in previous experiments.  $\text{Ag}^{113}$  was produced by bombarding thorium metal with 45-Mev protons for 10 min. The use of short irradiations and rapid chemical separations, followed by a decay period of up to 36 hr, gave  $\text{Ag}^{113}$  essentially free of 3.2 hr  $\text{Ag}^{112}$ , which is semishielded by its parent 21 hr  $\text{Pd}^{112}$ . Typical gamma spectra are illustrated with the energies and relative abundances tabulated. (B.O.G.)

## 17359

NOTE ON THE HYPERFINE STRUCTURE OF THE  $2s^22p^2$   $^2P_{3/2}$  STATE OF BORON 10 AND 11. H. Lew and R. S. Title (National Research Council, Ottawa). Can. J. Phys. **38**, 868-71(1960) June.

Measurements were made by the atomic beam magnetic resonance method to detect hyperfine structure anomalies for  $\text{B}^{10}$  and  $\text{B}^{11}$ . The measurements show that the anomaly is zero to within 2 parts in  $10^5$ . Of the numerous Zeeman lines present, three lines for each isotope were chosen for careful measurement. The procedures used in these measurements are given. (B.O.G.)

## 17360

A NOTE ON THE DECAY OF  $\text{Cs}^{132}$ . G. N. Whyte, Balraj Sharma, and H. W. Taylor (Queen's Univ., Kingston, Ont.). Can. J. Phys. **38**, 877-80(1960) June.

Cesium-132 decays to xenon-132 by orbital-electron capture followed by the emission of a single  $\gamma$  ray of about 0.67-Mev energy. The half life was found to be  $6.48 \pm 0.03$  days, and resulting  $\gamma$ -ray energy was  $0.6679 \pm 0.0004$  Mev. (B.O.G.)

## 17361

STUDY OF THE 6.76 AND 7.30 Mev LEVELS OF  $\text{B}^{11}$  BY THE  $\text{B}^{10}(\text{d},\text{p})\text{B}^{11}$  REACTION. Serge Gorodetzky, Michel Croissiaux, André Gailmann, Pierre Fintz, Jacques Samuel, and Gabriel Bassompierre. Compt. rend. **250**, 3153-5(1960) May 9. (In French)

For the study of the 6.76- and 7.30-Mev levels of  $\text{B}^{11}$ , the proton distribution from the  $\text{B}^{10}(\text{d},\text{p})$  reaction was measured by the method of  $\text{p}-\gamma$  coincidences. The correlations in the d-p plane for  $\theta_p = 20^\circ$  are isotropic. For the 6.76-Mev level there exists a very sharp peak toward  $40^\circ$  which corresponds to  $l_n = 1$  for the orbital moment of the captured neutron. For the level at 7.30 Mev the peak at  $40^\circ$  is very sharp for which the value  $l_n = 1$  for the orbital moment of the captured neutron can be attributed. The angular distributions of the protons for  $E_d = 1.25$  Mev are graphed relative to both energy levels. (J.S.R.)

## 17362

ABSOLUTE MEASUREMENT OF SOME  $\alpha$  ENERGIES. Albrecht Rytz. Compt. rend. **250**, 3156-8(1960) May 9. (In French)

The absolute energies of the  $\alpha$  radiation of  $\text{Po}^{210}$ ,  $\text{Po}^{214}$ ,  $\text{Bi}^{211}$ , and  $\text{Bi}^{212}$  were determined by magnetic spectrography with field controlled by nuclear resonance and absolute measurement of the trajectory lengths. (tr-auth)

## 17363

PHOTOSPLITTING OF  $\text{N}^{14}$  NUCLEI. A. P. Komar, Ya. Krzhemenek, and I. P. Yavor (Inst. of Physics and Tech., Academy of Sciences, USSR). Doklady Akad. Nauk S.S.R. **131**, 283-5(1960) Mar. 11. (In Russian)

Photofission of nitrogen, in particular the mechanism of  $(\gamma, \text{np})$  with large yield, was investigated. The experiments were carried out with a Wilson chamber filled with nitrogen and helium at partial pressures of 390 and 500 mm mercury, respectively, and maximum  $\gamma$  bremsstrahlung energy of 90 Mev. The data on relative yield,

based on 2633 events, are shown. The total  $\gamma$  absorption cross section is  $9.8 \pm 0.8$  mb/Q. The total integral cross section for  $\gamma$  absorption by  $N^{14}$  was 0.3 Mev barn. The energy spectra and angular distribution of protons from  $N^{14}(\gamma, p)C^{13}$  and  $N^{14}(\gamma, np)C^{12}$  reactions are plotted and analyzed. (R.V.J.)

17364

QUADRUPOLE CORRELATIONS IN LIGHT NUCLEI. V. G. Solov'ev (Joint Inst. for Nuclear Research, Dubna, USSR). Doklady Akad. Nauk S.S.R. 131, 286-9(1960) Mar. 11. (In Russian)

Interactions leading to quadrupole correlations of  $\alpha$ -particle type nuclei are investigated. Certain regularities in the bond energies of nucleons in light nuclei are analyzed by the shell model, with considerations for pair and quadrupole correlations. The quadrupole correlations disappear with neutron numbers exceeding the number of protons, explaining the variation in  $\alpha$ -particle property changes in nuclei with mass number A larger than 40. (R.V.J.)

17365

ON THE BREADTHS OF ANNIHILATION LINES IN COPPER AND IN GOLD. Bronislaw Średniawa (Univ. of Zurich). *Helv. Phys. Acta* 33, 131-42(1960). (In English)

The breadths of annihilation lines produced in the annihilation process of electrons and positrons are calculated for copper and gold. Two models are considered: (1) The Fermi gas model of conduction electrons and  $Cu^+$  or  $Au^+$  ions and (2) The model where the atoms exist complete in the crystal, but where owing to the influence of the crystal the outer shell 4s of Cu is so much compressed that it overlaps with the 3d shell (and for Au the 6s shell overlaps with the 5d shell). The breadths due to conducting electrons and the electrons in different shells of the Cu and Au ions are calculated. By comparison of the results with the experimental data it is shown that in the first model the contribution of conducting electrons to the breadth of the annihilation line is negligible. For both models the largest contribution stems from the most external complete shell but in Cu about 5% and in Au about 40 to 50% of the annihilations take place in the next inner shells of the atoms. (auth)

17366

SPIN WAVES IN COMPLEX EXCHANGE-COUPLED LATTICES AND NEUTRON SCATTERING. A. W. Sáenz (U. S. Naval Research Lab., Washington, D. C.). *J. Appl. Phys.* 31, Suppl. to No. 5, 108S-9S(1960) May.

A spin-wave theory of Holstein-Primakoff type is developed for exchange-coupled lattices with an arbitrary number n of magnetic ions per primitive magnetic unit cell. This theory is used to obtain a cross-section formula for the one-magnon zero-phonon scattering of arbitrarily polarized neutrons by such lattices for the case of complete orbital quenching of the magnetic ions thereof. For  $n > 1$ , this equation can be reduced to a simple approximate form in a limiting case, of interest for certain ferrimagnets, which involves only the scattering of "acoustic" magnons of sufficiently large wavelengths. The parallelism between this last result and the specialization of the above cross section formula for simple ferromagnets ( $n = 1$ ) is pointed out. (auth)

17367

HYPERFINE INTERACTIONS IN MAGNETIC MATERIALS BY  $\gamma$ - $\gamma$  ANGULAR CORRELATION MEASUREMENTS. M. E. Caspari and S. Frankel (Univ. of Pennsylvania, Philadelphia) and M. A. Gilleo (Lockheed Aircraft Corp.,

Palo Alto, Calif.). *J. Appl. Phys.* 31, Suppl. to No. 5, 320S-1S(1960) May.

A method for measuring hyperfine interactions in magnetic materials by  $\gamma$ - $\gamma$  angular correlation techniques is discussed. The change in the anisotropy of the 1415-122 Kev  $\gamma$ - $\gamma$  angular correlation following the K capture of  $Eu^{152}$  in neutron irradiated polycrystalline samples of Europium iron garnet enriched in  $Eu^{151}$  has been measured as a function of temperature without applied magnetic field, and the rotation of the angular correlation pattern was observed when a magnetic field was applied perpendicular to the plane containing the  $\gamma$  counters. From these experiments, the effective magnetic field acting at the europium nuclei immediately after the radioactive decay can be obtained. (auth)

17368

THE THERMAL NEUTRON CROSS-SECTION OF THE REACTION  $Cs^{137}(n, \gamma)Cs^{138}$ . Donald C. Stupegia (Argonne National Lab., Ill.). *J. Nuclear Energy, Pt. A, Reactor Sci.* 12, 16-20(1960) May.

The thermal neutron cross section for the reaction  $Cs^{137}(n, \gamma)Cs^{138}$  was found to be  $0.110 \pm 0.033$  barns in a flux having a resonance flux,  $\phi_r/\phi_{th}$ , equal to 0.00277, where  $\phi_r/\phi_{th}$  is the resonance flux per unit interval of  $\ln E$ , per unit thermal flux, and the resonance neutron energy ranges from 0.4 ev up to the energy of fission neutrons. (auth)

17369

PILE OSCILLATOR MEASUREMENTS OF RESONANCE ABSORPTION INTEGRALS. R. B. Tattersall, H. Rose, S. K. Pattenden, and D. Jowitt (Atomic Energy Research Establishment, Harwell, Berks, Eng.). *J. Nuclear Energy, Pt. A, Reactor Sci.* 12, 32-46(1960) May.

Measurements of the resonance absorption integral cross sections of some 35 materials are reported, and a table is given for 43 materials. The effective cross sections of the materials concerned were measured by the Dimple pile oscillator in both a pure thermal neutron spectrum and in one with an appreciable epithermal component, the difference between the cross sections found in these two cases leading directly to the resonance absorption integral. Experiments were also performed to measure the amount of self screening in many of the samples. The cross sections are compared with other experimental results, and also with estimates of the resonance integrals deduced from resonance parameter data. (auth)

17370

COPPER SPALLATION BY PROTONS WITH AN ENERGY OF 680 MEV. A. K. Lavruchina (Lavruchina), L. D. Krasavina, F. I. Pavlotskaya (Pavlockaja), and I. M. Grechishcheva (Grečiščeva). *Kernenergie* 1, 119-23 (1958) Feb. (In German)

Results are presented of a radiochemical study of the products of Cu spallation by 680-Mev protons. These results along with an interpolation of the yields of nuclei in immediate form are not well known. They make it possible to give a complete picture of the remaining products and to draw some conclusions with regard to the different fundamental properties of the processes. The total spallation cross section of copper is  $0.6 \times 10^{-24}$  cm<sup>2</sup> or 56% of the geometric cross section. Of the total effective cross section for formation of Cu spallation products, Co, Ni, and Cu make up 60%, an important contribution. The yield of isotopes increased in the direction of the stable nucleus region. The spallation process in Cu nuclei caused neutrons and protons to be expelled in the ratio  $\Sigma n/\Sigma p$  = approximately 1.3. The release of  $\alpha$  particles is prob-

ably the result of successive expulsions of 4 nucleons. In spallation of nuclei by high-energy particles there is no evidence of effects on nuclear structure. A comparison of the characteristics of the Cu spallation process by 680-Mev protons with values obtained in research on Cu spallation by different particles with energies from 190 Mev to 2.2 Bev makes it possible to make some statements about the effects of the nature and energy-gain of the bombarding particle on the spallation process. (tr-auth)

17371

SUCCESSIVE NEUTRON CAPTURE IN ANTIMONY. A. N. Murin, V. D. Nefedov, D. K. Popov, and V. I. Baranovskii (Baranovskij). *Kernenergie* 1, 302(1958) Apr. (In German)

The existence of a double neutron capture by  $Sb^{123}$  was established by identification of  $Te^{125m}$  activity in neutron-irradiated Sb. The activation cross section of  $Sb^{124}$  is of the order of  $2 \times 10^3$  barns. (T.R.H.)

17372

ELECTRIC AND MAGNETIC MOMENTS OF ODD-NEUTRON NUCLEI ON THE SINGLE CONFIGURATION MODEL. Hajime Narumi (Kyoto Univ.) and Hiroyuki Nagai (Inst. for Chemical Research, Kyoto). *Nuclear Phys.* 16, 193-205(1960) May (1). (In English)

Without taking into account the effect of configuration mixing, an attempt is made to derive the electric and magnetic moments of odd-neutron nuclei on the basis of the single configuration model. The quadrupole moments of odd-neutron nuclei may be obtained by the promotion of two protons from the zeroth order proton state of seniority zero to the states of seniority two. These mixing coefficients of the ground state are determined by fitting the wave function to the magnetic moment of the odd-neutron nucleus considered. Thus a fairly good agreement is found between the calculated and observed values except for the nuclei with very large quadrupole moments and for the nuclei in the vicinity of each closed shell. The quadrupole and hexadecapole moments of the first excited state of  $Cd^{111}$  are evaluated. (auth)

17373

RESONANT ABSORPTION OF THE GAMMA RADIATION FROM THE  $Ne^{22}(p,\gamma)Na^{23}$  REACTION. W. L. Mouton and P. B. Smith (Rijksuniversiteit, Utrecht). *Nuclear Phys.* 16, 206-14(1960) May (1). (In English)

The gamma rays emitted in the reaction  $Ne^{22}(p,\gamma)Na^{23}$  at  $E_p = 637$  kev were selectively absorbed in sodium fluoride, using the technique of collision produced Doppler shift. Resonant absorption of the 9.40 Mev gamma rays occurs at  $74.3^\circ$  with respect to the proton beam direction. The instrumental resolution curve was determined by observing the resonant absorption of the 12.33 Mev gamma radiation from the reaction  $Al^{27}(p,\gamma)Si^{28}$  at  $E_p = 771$  kev. The absorption curve for  $Na^{23}$  is broader than the measured instrumental curve and therefore it was possible to determine directly the total width of the resonance level as  $460 \pm 360$  ev. From the absorption integral, together with this value of the total width, the radiation width ( $\Gamma_{\gamma_0}$ ) for transitions to the ground state is found to be  $2.7 \pm 1.1$  ev. This result is in agreement with the value  $\Gamma_{\gamma_0} = 2.0 \pm 0.5$  ev, found from a yield measurement. No definite assignment of parity can be made on the basis of the partial widths obtained. (auth)

17374

CLASSIFICATION OF BETA- AND GAMMA-RAY TRANSITIONS BETWEEN INTRINSIC STATES IN DEFORMED EVEN-MASS NUCLEI. C. J. Gallagher (Univ. of Copen-

hagen). *Nuclear Phys.* 16, 215-30(1960) May (1). (In English)

The description of intrinsic states of deformed even-mass nuclei by the product wave functions of the strong coupling model, using Nilsson wave functions to describe the intrinsic particle configurations, is shown to lead to selection rules which depend on the coupling between the last two particles. In the case in which the coupling in the final and initial states is the same, the description leads, in the asymptotic limit of the Nilsson wave functions, to selection rules similar to those proposed earlier for odd-mass nuclei. For nuclear states with different relative couplings the selection rules lead most frequently to K-forbiddenness. It is shown that, if the non-transforming particle in the two-particle product wave function is not the same in the final and initial states, the resulting two-particle transition is formally forbidden. The experimental transition rates in even-mass nuclei to which definite configurations can be assigned are observed to fall within well-defined ranges characteristic of the degree of forbiddenness predicted by the selection rules. The data on log ft-values indicate that single-particle transitions occur with essentially the same speed whether the transforming particle is in an odd-mass or an even-mass nucleus. (auth)

17375

ISOMERS IN  $N = 81$  NUCLEI. K. Kotajima and H. Morinaga (Tohoku Univ., Sendai). *Nuclear Phys.* 16, 231-45(1960) May (1). (In English)

Two new isomers,  $Nd^{141m}$  and  $Sm^{143m}$ , were found from the  $(\gamma, n)$  reactions on natural Nd and Sm. Their energies and half lives as well as those of previously known  $Ce^{139m}$  and  $Xe^{135m}$  were determined very precisely by careful and repeated measurements. Systematic variations of the decay characteristics of these four isomers together with those of  $Te^{133m}$  and  $Ba^{137m}$  are discussed qualitatively. (auth)

17376

ALPHA SPECTRA OF  $Bi^{214}$  AND REMARKS ON SOME  $Bi$   $\alpha$ -EMITTERS. R. J. Wallen and G. Bastin-Scoffier (Centre National de la Recherche Scientifique, Paris). *Nuclear Phys.* 16, 246-63(1960) May (1). (In French)

Alpha-spectrography of  $Bi^{214}$ (RaC) shows, besides the 2 known groups, 4 other weak ones. Energies and intensities are, in Mev and  $10^{-6}$  units:  $5.512(82) - 5.448(116) - 5.268(12.5) - 5.184(1.3) - 5.023(0.45) - 4.941(0.52)$ . Systematics of hindrance factors of  $Bi$   $\alpha$ -emitters suggest a shell-model interpretation of the corresponding levels, which show, for the 208 and 210 isotopes of Tl, the same sequence of multiplets. (auth)

17377

NUCLEAR POLARIZATION OF  $Co^{55}$ . Rudolf W. Bauer and Martin Deutsch (Massachusetts Inst. of Tech., Cambridge). *Nuclear Phys.* 16, 264-77(1960) May (1). (In English)

The angular distribution and linear polarization of the gamma rays emitted from 18-hr  $Co^{55}$ , polarized at low temperatures in cerium-magnesium nitrate crystals, were measured. The amplitude mixing ratios  $\delta(E2/M1)$  of mixed multipole gamma transitions in  $Fe^{55}$  were determined. With a spin of  $1/2$  for  $Co^{55}$ , a spin sequence of  $1/2 \rightarrow 5/2 \rightarrow 3/2$  is found in the main decay in  $Fe^{55}$ , and for the 0.935 Mev gamma ray a  $\delta$  of  $+0.36 \pm 0.11$ . A possible spin sequence  $5/2 \rightarrow 1/2 \rightarrow 3/2$  in  $Fe^{55}$  was eliminated by the linear polarization measurements. The ratio of the nuclear g-values of  $Co^{55}$  and  $Co^{56}$  was found from a simultaneous measurement of the angular distribution of the gamma rays from the two isotopes grown into the same crystals. The magnetic mo-

ment of  $\text{Co}^{65}$  is  $5.3 \pm 0.4$  nm, if the 1.03 Mev beta branch is predominantly a G.T. transition, or  $4.6 \pm 0.4$  nm, if a pure Fermi transition. (auth)

17378

NEUTRON TOTAL CROSS-SECTIONS IN THE 12 TO 21 MEV REGION. G. J. McCallum, G. S. Mani, and A. T. G. Ferguson (Atomic Energy Research Establishment, Harwell, Berks, Eng.). *Nuclear Phys.* **16**, 313-17 (1960) May (1). (In English)

Measurements were made of the neutron total cross sections of a number of elements for neutron energies between 12 to 21 Mev. The results are discussed in terms of a simple optical model. (auth)

17379

NUCLEAR RADII FROM NEUTRON SCATTERING.

Richard Wilson (Harvard Univ., Cambridge, Mass.). *Nuclear Phys.* **16**, 318-19 (1960) May (1). (In English)

It is shown how determinations of nuclear radii by neutron and electron scattering can be reconciled, with the exception of a possible anomaly for lithium. (auth)

17380

MODIFICATION OF THE FORM OF POTENTIAL IN AN EXCITED NUCLEUS AND ITS EFFECT ON THE BARRIER TRANSMISSION COEFFICIENT. J. Németh (Central Research Inst. for Physics, Budapest). *Nuclear Phys.* **16**, 331-8 (1960) May (1). (In English)

The transmission coefficient of the nuclear potential barrier is calculated by taking into account the fact that the density distribution of an excited nucleus differs from that of one in the ground state. As an example the potential barrier of an excited nucleus of mass number 40 is determined on the basis of the statistical model and it is found that for 15 Mev excitation energy the transmission coefficient for protons emitted with 2 Mev energy is twice as large as that for a nucleus in the ground state. (auth)

17381

ON THE DECAY OF  $\text{Ru}^{105}$ . R. A. Ricci, S. Monaro, and R. Van Lieshout (Instituut voor kernfysicaal Onderzoek, Amsterdam). *Nuclear Phys.* **16**, 339-50 (1960) May (1). (In English)

The decay of 4.4 hr  $\text{Ru}^{105}$  was studied by means of scintillation techniques and with a double focusing spectrometer. Eight gamma rays were observed in addition to the isomeric transition from the 30 sec  $\text{Rh}^{105}$  daughter. This last one was shown to be of E3 character. A decay scheme is proposed which shows similarities to those of neighboring nuclides. The strong 725 kev gamma ray does not populate the isomeric state at 129 kev, but leads directly to the 35-hr ground state. (auth)

17382

NOTE ON THE DECAY OF THE NEW NUCLEIDE  $\text{Cr}^{68}$ .

J. Dropesky, A. W. Schardt, and T. T. Shull (Los Alamos Scientific Lab., N. Mex.). *Nuclear Phys.* **16**, 357-9 (1960) May (1). (In English)

$\text{Cr}^{68}$  was identified and found to decay with a 5.94 min half-life. A 1.5-Mev  $\beta$ -group and a 26-, 83-kev  $\gamma$ -ray cascade were observed in the decay. (auth)

17383

$\text{Li}^7(\alpha, p)\text{Be}^{10}$  AND  $\text{Li}^6(\alpha, p)\text{Be}^9$  REACTIONS AT 30 MEV.

P. R. Klein, N. Cindro, L. W. Swenson, and N. S. Wall (Massachusetts Inst. of Tech., Cambridge). *Nuclear Phys.* **16**, 374-6 (1960) May (1). (In English)

Angular distributions for the  $\text{Li}^7(\alpha, p)\text{Be}^{10}$  and  $\text{Li}^6(\alpha, p)\text{Be}^9$  reactions were obtained for the ground state of the residual nucleus, using 30 Mev  $\alpha$ -particles. In the case of the  $\text{Li}^7$

reaction an angular distribution was obtained leaving the residual nucleus in the first excited state. Of particular interest in all three of these angular distributions is the sharp increase in differential cross section at back angles. It is shown that the present theories of direct reactions are inadequate to account for this structure. (auth)

17384

ELECTRON CAPTURE AND LOSS BY HYDROGEN ATOMS IN MOLECULAR HYDROGEN. R. Curran and T. M. Donahue (Univ. of Pittsburgh). *Phys. Rev.* **118**, 1233-6 (1960) June 1.

Measurements of the single electron capture and loss cross sections for atomic hydrogen in molecular hydrogen are reported for atoms of energies 4 to 35 kev. Peaks in the loss cross section are found which appear to be associated with the formation of negative ions in the target gas. (auth)

17385

$(p, p' \gamma)$  ANGULAR CORRELATIONS AT LOW ENERGY.

H. J. Hausman, G. F. Dell, and H. F. Bowsher (Ohio State Univ., Columbus). *Phys. Rev.* **118**, 1237-46 (1960) June 1.

At an incident proton bombarding energy of 6.5 Mev, angular correlations were measured between protons scattered inelastically from various even-even nuclei and the decay gamma rays from the first excited states of these nuclei. The angular correlation experiments reported are  $\text{C}^{12}(p, p' \gamma)$  4.4 Mev,  $\text{Li}^7(p, p' \gamma)$  0.48 Mev,  $\text{Cr}^{52}(p, p' \gamma)$  1.44 Mev,  $\text{Ne}^{20}(p, p' \gamma)$  1.63 Mev,  $\text{Si}^{28}(p, p' \gamma)$  1.78 Mev, and  $\text{S}^{32}(p, p' \gamma)$  2.25 Mev, which were done for proton detector angles of 60°, 90°, and 120°. The measured angular correlation functions are all of the form  $A + B [\sin^2(\theta - \theta_0)]$ , where  $\theta_0$  is the axis of symmetry. None of the symmetry directions agreed with predictions of the simple direct-reaction theories. However, the symmetry direction for the correlation functions changed with proton detector angle for the experiments on  $\text{C}^{12}$ ,  $\text{Ne}^{20}$ , and  $\text{S}^{32}$ , for the experiment of  $\text{Si}^{28}$  the angular correlation functions were symmetric about 90°, independent of proton detector angle. The results of the angular correlation experiments appear to be consistent with a collective interaction involved in these direct-type reactions rather than a nucleon-nucleon type collision at the nuclear surface. (auth)

17386

LEVELS IN  $\text{Bi}^{210}$  FROM THE  $\text{Bi}^{209}(\text{d}, \text{p})$  REACTION. G. B. Holm, J. R. Burwell, and D. W. Miller (Indiana Univ., Bloomington). *Phys. Rev.* **118**, 1247-56 (1960) June 1.

Q values and differential cross sections were measured for nuclear states in  $\text{Bi}^{210}$  excited by the  $\text{Bi}^{209}(\text{d}, \text{p})$  reaction. A previously unobserved group with  $Q = 2.35 \pm 0.03$  Mev was found, corresponding to a state with probable proton-neutron assignment  $(h_{\frac{1}{2}}, g_{\frac{1}{2}})$ . The observed Q value for this state is in good agreement with the Q value expected for the 1- ground state of RaE. Groups of states with mean excitation of 0.41, 0.88 and 1.4, 2.02, 2.56, 2.81, 3.15, and 4.03 Mev were found, and neutron assignments of  $g_{\frac{1}{2}}, i_{\frac{1}{2}}, d_{\frac{3}{2}}, s_{\frac{1}{2}}, g_{\frac{3}{2}}, d_{\frac{5}{2}},$  and  $(h_{\frac{5}{2}})$  were suggested. A comparison with theoretical calculations by Newby and Konopinski for the  $(h_{\frac{1}{2}}, g_{\frac{1}{2}})$  group of states gives further support to their observation that a calculation of levels in the neighborhood of  $\text{Pb}^{208}$  is far less accurate when the extra-core interaction type is proton-neutron than when it is neutron-neutron or proton-proton. (auth)

17387

ANALYSIS OF THE TWO-MODE-OF-FISSION HYPOTHESIS. George P. Ford (Los Alamos Scientific Lab., N. Mex.). *Phys. Rev.* **118**, 1261-70 (1960) June 1.

Mass yields for gamma fission of  $U^{238}$ , proton fission of  $Th^{232}$ , alpha fission of  $U^{238}$ , and deuteron fission of normal uranium were examined in terms of vector spaces for consistency with the hypothesis that for each target and projectile there are two and only two modes of fission. The first three cases are on the whole consistent with the hypothesis. The fourth is not consistent with the hypothesis; the measured yields include some yields from neutron fission. Some consequences of the hypothesis with the added requirement of non-negative yields and non-negative coordinates are derived. (auth)

## 17388

ANALYSIS OF (d,t) PICK-UP REACTIONS. Amélia Império Hamburger (Univ. of Pittsburgh). Phys. Rev. **118**, 1271-8 (1960) June 1.

A comparison is made between (p,d) [or (d,p)] and (d,t) pick-up reactions involving transitions between the same nuclear levels. Eleven cases are studied, having transfer orbital angular momentum  $l = 0, 1$  or  $2$ , for nuclei from  $Li^6$  to  $Mg^{25}$  (also  $Sn^{117}$ ), and for incident energies of the order of 15 Mev. It is found that if the differential cross sections of the corresponding (d,p) and (d,t) reactions are plotted as functions of momentum transfer the curves differ by a factor independent of angle. This property holds primarily in the region of the first peak of the angular distribution. Towards larger angles the curves differ in shape. Because of the proportionality between the curves in the forward direction, it is possible to obtain an expression for extracting the stripping reduced width of (d,t) reactions. This reduced width corresponds to the reduced width of the same transition when studied by a (d,p) process. No emphasis is placed on the interpretation of the results in terms of the structure of the triton. An attempt is made to determine the triton momentum transform directly from an analysis of the  $d + d \rightarrow p + t$  experiments, considering these as stripping reactions. It was not possible to apply the curves thus obtained to the (d,t) reactions in the heavier nuclei. The experiment  $F^{18}(d,t)F^{18}$  ground state was performed with 14.8-Mev deuterons, for angles  $\theta_{lab}$  between  $5^\circ$  and  $45^\circ$ . The results extend the information about transitions with  $l = 0$ . (auth)

## 17389

CONVERSION, K-AUGER, AND L-AUGER SPECTRA OF  $Hg^{199}$ . J. C. Nall, Q. L. Baird, and S. K. Haynes (Vanderbilt Univ., Nashville). Phys. Rev. **118**, 1278-88 (1960) June 1.

The high resolution of the spectrometer made possible the detailed study of K, L, M, N + O conversion lines and the K- and L-Auger spectra of  $Ag^{199}$  with the following results (here  $\omega$  and  $a$  are the fluorescence and Auger yields and  $f_{ij}$  is the Coster-Kronig transfer probability): K-Auger lines,  $\omega_K = 0.952 \pm 0.003$ , KLL:KLX:KXY =  $1.00:0.496 \pm 0.015:0.094 \pm 0.003$ , and  $KL_1L_1:KL_1L_2:KL_1L_3:KL_2L_2:KL_2L_3:KL_3L_3 = 1.00:1.32 \pm 0.1:0.85 \pm 0.06:0.40 \pm 0.03:1.28 \pm 0.08:0.76 \pm 0.05$ ; L-Auger lines, LMM:LMX:LXY =  $1.00:0.30 \pm 0.03:0.015 \pm 0.004$ , and  $a_L = 0.590 \pm 0.04$ ,  $\omega_L = 0.410 \pm 0.04$ ,  $a(L_1) = 0.16 \pm 0.02$ ,  $a(L_2) = 0.46 \pm 0.04$ ,  $\omega(L_2) = 0.32 \pm 0.03$ , and Coster-Kronig yields,  $f(L_2L_3X) = 0.22 \pm 0.04$ ,  $f(L_1L_2X) + f(L_1L_3X) = 0.74 \pm 0.04$ . In addition considerable detail was obtained on the KLX and L-Auger fine structure. The results of all of the known L-Auger yield work since 1952 have been tabulated in this paper. The conversion line results are compared and combined with those of two other groups to give an optimum set of relative intensities. From these are obtained for the 51-kev transition,  $\alpha(L_1): \alpha(L_2): \alpha(L_3): \alpha(M): \alpha(N): \alpha(O) = 1.00:0.087 \pm 0.010:0.012 \pm 0.007:0.212 \pm 0.04:0.068 \pm$

$0.005:0.016 \pm 0.001$ ; 156-kev transition,  $\alpha(K): \alpha(L_1): \alpha(L_2): \alpha(L_3): \alpha(M): \alpha(N+O) = 1.00:0.144 \pm 0.015:0.830 \pm 0.028:0.586 \pm 0.018:0.418 \pm 0.017:0.107 \pm 0.005$ ; 209-kev transition,  $\alpha(K): \alpha(L_1): \alpha(L_2): \alpha(L_3): \alpha(M): \alpha(N+O) = 1.00:0.155 \pm 0.005:0.029 \pm 0.003:0.0085 \pm 0.0003:0.050 \pm 0.006:0.0130 \pm 0.004$ , where  $\alpha$  is the internal conversion coefficient. In addition, by use of Rose's Tables the 51-kev transition was determined to be  $3.3 \pm 1 \times 10^{-4}$  E2, and the 209-kev transition  $0.113 \pm 0.01$  E2, and the E2 assignment of the 158-kev transition was confirmed to better than 1%. The relative gamma-ray intensities are 209 kev: 51 kev: 158 kev =  $1.000:0.045 \pm 0.002:4.59 \pm 0.23$ . (auth)

## 17390

DECAY OF RUTHENIUM-105. Babulal Saraf, P. Harihar, and R. Jambunathan (Atomic Energy Establishment, Trombay, India). Phys. Rev. **118**, 1289-92 (1960) June 1.

The decay of  $Ru^{105}$  was studied employing two scintillation spectrometers in coincidence. It is found that  $Ru^{105}$  decays to the excited levels of  $Rh^{105}$  with the emission of six  $\beta$  groups, with end-point energies of  $\sim 125$ ,  $525$ ,  $915$ ,  $1080$ ,  $1150$ , and  $\sim 1800$  kev, the branching ratios being approximately  $\sim 0.002$ ,  $0.068$ ,  $0.11$ ,  $0.30$ ,  $0.51$ , and  $\sim 0.01$ , respectively. The subsequent  $\gamma$  rays have the energies of  $130$ ,  $265$ ,  $320$ ,  $400$ ,  $475$ ,  $485$ ,  $665$ ,  $725$ ,  $875$ ,  $960$ ,  $1350$ , and  $1750$  kev. From  $\gamma$ - $\gamma$  and  $\beta$ - $\gamma$  coincidence measurements, a level scheme of  $Rh^{105}$  was worked out, showing the excited states at  $130$ ,  $395$ , (or  $530$ ),  $475$ ,  $725$ ,  $795$ ,  $960$ ,  $1350$ , and  $1750$  kev. (auth)

## 17391

HE-ION INDUCED REACTIONS OF ALUMINUM AND MAGNESIUM. Richard H. Lindsay and Robert J. Carr (Washington State Univ., Pullman). Phys. Rev. **118**, 1293-7 (1960) June 1.

The  $Al^{27}(\alpha, 3p)Mg^{28}$  and  $Mg^{26}(\alpha, 2p)Mg^{28}$  reactions produced by the bombardment of aluminum and magnesium targets with 42 Mev He ions were studied. The excitation functions for these reactions are presented. At 40-Mev He-ion bombarding energy, the cross section for the  $(\alpha, 3p)$  is about 80 microbarns and the peak yield of the  $(\alpha, 2p)$  reaction observed at 34 Mev is 1.65 mb. Excitation functions are also given for the production of  $Na^{22}$  from the bombardment of aluminum with 30 to 42 Mev He ions, which proceeds chiefly through the reaction  $Al^{27}(\alpha, 2\alpha)Na^{22}$ , and of  $Na^{24}$  from the bombardment of natural magnesium, primarily through the  $Mg^{25}(\alpha, \alpha p)Na^{24}$  reaction. (auth)

## 17392

ENERGY SPECTRA AND ANGULAR DISTRIBUTION OF PHOTONEUTRONS FROM CARBON. V. Emma, C. Milone, and A. Rubbino (Università, Catania, Italy and Centro Siciliano di Fisica Nucleare, Catania, Italy). Phys. Rev. **118**, 1297-1301 (1960) June 1.

Energy spectra and angular distribution of photoneutrons from carbon are studied by irradiation with a 30-Mev bremsstrahlung beam. The spectra exhibit a fine structure from which the following levels in  $C^{12}$  may be distinguished:  $21.4$ ,  $22.2$ ,  $22.9$ ,  $23.6$ ,  $(24.3)$ ,  $24.8$ , and  $25.6$  Mev. Many of these coincide with levels found in the  $C^{12}(\gamma, p)$  and  $C^{12}(\gamma, 3\alpha)$  reactions. Photoneutron emission occurs predominantly by transition to the ground state of  $C^{11}$ . The angular distribution is of the form  $1 + 1.5 \sin^2\theta$  for all neutrons having energy  $E_n > 3$  Mev. This distribution agrees with that expected according to Wilkinson's independent-particle model for ejection from the  $l = 1$  orbit. (auth)

## 17393

SYSTEMATICS OF NEUTRON SEPARATION ENERGIES.

K. N. Geller, J. Halpern, and E. G. Muirhead (Univ. of Pennsylvania, Philadelphia). Phys. Rev. **118**, 1302-12 (1960) June 1.

Photoneutron thresholds for 73 isotopes were measured by radioactivity and neutron detection methods using a 25-Mev betatron. The neutron separation energies inferred from the observed thresholds are in general agreement with the values predicted from mass data and reaction energies. Several discrepancies are observed between threshold and neutron binding energies where ground state transitions require a spin change  $\geq 7/2$ . For these nuclei, the threshold energies are consistent with neutron emission leaving the residual nucleus in an excited state. (auth)

17394

BETA- AND GAMMA-RAY SPECTRA OF  $\text{Pd}^{111}$ . William W. Pratt and Robert G. Cochran (Pennsylvania State Univ., University Park). Phys. Rev. **118**, 1313-15 (1960) June 1.

Beta rays of 2.18 Mev and gamma rays of 0.377, 0.580, 0.620, 0.810, 1.380, and 1.450 Mev were found in the decay of the 22-minute isomer of  $\text{Pd}^{111}$ . Beta rays of 2.02 Mev and gamma rays of 0.170 and 1.690 Mev were found associated with the 5.5-hour isomer. Although the beta-ray groups may both represent the decay of the 22-minute state, the dissimilarity of the gamma-ray spectra implies some degree of beta-ray branching from the 5.5-hour state. (auth)

17395

BETA DECAY OF  $\text{Y}^{91}$ . O. E. Johnson and W. G. Smith (Purdue Univ., Lafayette, Ind.). Phys. Rev. **118**, 1315-18 (1960) June 1.

The decay of  $\text{Y}^{91}$  was studied using NaI(Tl) scintillation counters and a  $4\pi$  beta-ray scintillation spectrometer. A single gamma ray with a measured energy of  $1.208 \pm 0.010$  Mev was observed. The shape and end-point energy of the weak ( $\sim 0.3\%$ ) beta group in coincidence with the 1.208-Mev gamma ray was measured. The end-point energy was determined to be  $0.319 \pm 0.010$  Mev. The experimental shape factor is clearly in disagreement with that predicted for a once-forbidden unique transition,  $\Delta I = 2$  (yes). The 0.319-Mev beta spectrum yields a shape factor which may, within experimental accuracy, be interpreted as a statistical shape. These measurements yield a  $\text{Y}^{91}$ - $\text{Zr}^{91}$  mass difference of  $1.527 \pm 0.014$  Mev. (auth)

17396

EFFECTS OF A NUCLEAR OCTUPOLE MOMENT ON NEUTRON SCATTERING. Kirk W. McVoy (Brookhaven National Lab., Upton, N. Y.). Phys. Rev. **118**, 1323-30 (1960) June 1.

Recent applications of the nuclear optical model to the description of neutron scattering by spheroidal nuclei showed that "shape effects" are very important for highly deformed nuclei. It was also found that the "adiabatic approximation," which assumes the nucleus to be rigidly fixed in orientation throughout the scattering, is remarkably accurate for very low-energy (S-wave) neutrons. A detailed investigation was made of this approximation, showing that the major factor determining its validity for the heavy nuclei to which it has been applied is the large size of the "effective rotating mass" of the nucleus in comparison to the neutron mass. The effect of a "pear-shaped" deformation, or octupole moment, of the nuclear optical potential on the S-wave neutron strength function was investigated. (A square-edged potential well was used.) This was done for the very heavy nuclei,  $225 < A < 240$ , where the possibility of octupole deformations was suggested by other data. The effect of a small octupole moment for these particular nuclei was found to be largely masked by the nearly indis-

tinguishable effect of their large quadrupole moments, and, in view of the uncertainty in their quadrupole moments, neutron scattering at this time cannot be said to provide any positive evidence of octupole moments. On the contrary, if the quadrupole moments reported from Coulomb excitation measurements are employed, the measured neutron strength function puts an upper limit on the octupole moments of about one-third the quadrupole moment. More accurate data, both on the neutron strength function (as well as  $R'$ ) and on the quadrupole moments, would permit a more accurate estimate of the octupole moments. (auth)

17397

GROUND-STATE Q VALUES FOR THE  $\text{Si}^{30}(\text{p},\alpha)\text{Al}^{27}$  AND  $\text{O}^{16}(\text{p},\alpha)\text{N}^{13}$  REACTIONS. R. E. White and W. W. Buechner (Massachusetts Inst. of Tech., Cambridge). Phys. Rev. **118**, 1331-21 (1960) June 1.

Alpha-particle groups observed during the magnetic analysis of charged particles produced in the bombardment of silicon dioxide targets with 8- and 8.59-Mev protons were identified as arising from the reactions  $\text{Si}^{30}(\text{p},\alpha)\text{Al}^{27}$  and  $\text{O}^{16}(\text{p},\alpha)\text{N}^{13}$ . The corresponding Q values are  $-2.366 \pm 0.010$  Mev and  $-5.206 \pm 0.010$  Mev, respectively. (auth)

17398

INELASTIC SCATTERING OF HIGH-ENERGY PROTONS EXCITING A COLLECTIVE LEVEL OF NUCLEUS. K. Nishimura (Rutgers Univ., New Brunswick, N. J.). Phys. Rev. **118**, 1350-2 (1960) June 1.

An analysis is made of the angular distribution and polarization of 185-Mev protons inelastically scattered by carbon. A rough calculation using the distorted wave Born approximation shows, even though the quantitative agreement is poor, that the 4.4-Mev level of  $\text{C}^{12}$  may be interpreted as a collective state. (auth)

17399

LEVEL STRUCTURE OF NUCLEAR MATTER AND LIQUID  $\text{He}^3$ . K. A. Brueckner and Toshio Soda (Univ. of California, La Jolla); Philip W. Anderson (Bell Telephone Labs., Murray Hill, N. J.); and Pierre Morel (French Embassy, New York). Phys. Rev. **118**, 1442-6 (1960) June 1.

Using the K matrix as computed in the study of nuclear matter and liquid  $\text{He}^3$  as the effective interaction at the Fermi surface, the possible superfluidity of these systems has been investigated. A theory of the cooperative phenomenon valid for particle-particle interaction in states of arbitrary angular momentum has been developed following the methods of Bardeen, Cooper, and Schrieffer. It is found for states of relative angular momentum other than  $l = 0$  that the particle pairs must be correlated with respect to an arbitrary direction in the medium. As a result the change of structure of the Fermi surface is angularly dependent. An energy gap does not occur other than for  $l = 0$ , the particle excitation energy vanishing for certain orientations of the momentum. It is also shown that the specific heat shows a discontinuity at the transition temperature, but somewhat different from the case of  $l = 0$ . Application of these results to liquid  $\text{He}^3$  shows that the cooperative effects arise from the interaction in the state with  $l = 2$ , and that the transition temperature is at about  $0.1^\circ\text{K}$ . In nuclear matter the  $^1\text{S}_0$  interaction is very weak and probably repulsive at the Fermi surface, and the attractive  $^1\text{D}_2$  interaction gives a negligible energy shift. The  $^3\text{S}_1$  interaction is attractive and in nuclear matter gives a few-tenths of an Mev energy gap. These results suggest that in finite nuclei, with pairing of identical nucleons in the same shell, the cooperative effects are not strictly analogous to those in nuclear matter but instead are closely associated with the finite level spacing. (auth)

## 17400

ZEEMAN EFFECT IN THE RECOILLESS  $\gamma$ -RAY RESONANCE OF  $Zn^{67}$ . P. P. Craig, D. E. Nagle, and D. R. F. Cochran (Los Alamos Scientific Lab., N. Mex.). Phys. Rev. Letters **4**, 561-4 (1960) June 1.

Measurements are reported of the influence of the nuclear Zeeman effect and other perturbing factors upon the Mössbauer effect in  $Zn^{67}$  embedded in an enriched  $ZnO$  absorber lattice at temperatures below the helium lambda transition (2.175°K). Ways in which the design of the experiment are affected by various perturbations are described. The resonance absorption pattern for the 93-kev line of  $Zn^{67}$  as a function of the magnetic field is given including corrections for background and unresolved  $\gamma$  rays of 30%. The major structural feature of the curve lies in the fact that the maximum resonance does not occur at zero field but is shifted to  $\sim 10$  gauss. A plausible explanation for this is that chemical shifts are superimposed upon the isotopic mass effect. (B.O.G.)

## 17401

METHOD FOR DETERMINING THE ORBITAL ANGULAR MOMENTUM IN  $K^-$ -d CAPTURE. Donald H. Miller (Univ. of California, Berkeley). Phys. Rev. Letters **4**, 568-70 (1960) June 1.

It is pointed out that the  $K^-$ -d orbital angular momentum determines the reaction rates for reactions which are fairly accessible experimentally, the nonmesonic capture reactions in deuterium. The discussion is confined to the  $K^- + d \rightarrow \Sigma^- + p$  reaction since it is easily recognized in a deuterium-filled bubble chamber and is known to occur at  $\sim 0.7\%$  when stopped  $K^-$  mesons are captured. If capture occurs predominantly from S orbitals, the fraction of nonmesonic absorptions observed at rest and in flight must be a continuous and slowly varying function of  $K^-$  momentum. The lower limits for fractions of nonmesonic absorptions expected in flight when  $K^-$  capture at rest occurs from either S or P atomic orbitals are given for  $K^-$  momenta of 50, 200, and 300 Mev/c. (B.O.G.)

## 17402

MUON ABSORPTION IN LIQUID HYDROGEN. Steven Weinberg (Univ. of California, Berkeley). Phys. Rev. Letters **4**, 575-8 (1960) June 1.

It is shown that it is possible to interpret the muon absorption rate in liquid hydrogen in terms of the basic  $(pn\mu\nu)$  interaction. The main problem is to calculate the rate for the process:  $(p\mu^-p) \rightarrow n + \nu + p$  in terms of muon absorption in atoms. The discussion applies to solid as well as liquid hydrogen, but it is confined to the case of isotopically pure ( $H^1$ ). Many of these assumptions may be tested by measuring the total hydrogen absorption rate over a range of hydrogen densities. (B.O.G.)

## 17403

QUADRUPOLE MOMENT OF  $Fe^{57m}$ . R. Bersohn (Columbia Univ., New York). Phys. Rev. Letters **4**, 609-10 (1960) June 15.

The quadrupole moment (Q) for  $Fe^{57m}$  is deduced from coupling constant data for  $Fe^{57m}$  in  $\alpha$ - $Fe_2O_3$  and for  $Al^{27}$  in  $\alpha$ - $Al_2O_3$ , using a model of the ionic lattices. The crystalline parameters of  $\alpha$ - $Al_2O_3$  and  $\alpha$ - $Fe_2O_3$  are so similar that the field gradient constant may be assumed to be the same for both, and two values of Q are obtained for  $Fe^{57m}$  using two different approaches, -0.33 and -0.19 barn. The latter is probably closer to the true value. (D.L.C.)

## 17404

LONG-LIVED LUTETIUM ISOTOPES. V. A. Romanov, M. G. Iodko, and V. V. Tuchkevich. Zhur. Eksptl. i Teoret. Fiz. **38**, 1019-26 (1960) Apr. (In Russian)

The conversion spectrum of the long-lived lutetium isotopes  $Lu^{173}$  and  $Lu^{174}$  is investigated. The relative conversion line intensity in the soft region of the spectrum (up to 250 kev) is measured in the  $Lu^{173}$  spectrum. The per cent ratio of the M1 + E2 mixture for 78.6 and 100.6 kev transitions is determined. Conversion lines were detected in the lutetium-174 spectrum which can be ascribed to transitions connected with the isomer state of  $Lu^{174}$  ( $E_{\gamma} = 44.7$  kev M1 transition and  $E_{\gamma} = 59.0$  kev M3 transition). The half life of the isomer state is  $\sim 90$  days. (auth)

## 17405

INVESTIGATION OF THE RELATIVE INTENSITIES OF SOME CONVERSION LINES IN THE SPECTRUM OF NEUTRON-DEFICIENT LUTETIUM ISOTOPES. M. G. Iodko, V. V. Tuchkevich, V. A. Romanov, and O. M. Kresin. Zhur. Eksptl. i Teoret. Fiz. **38**, 1027-30 (1960) Apr. (In Russian)

A prism spectrometer was employed to investigate a number of the more intense lines in the conversion spectrum of neutron-deficient Lu isotopes. The relative intensities and energies of the lines are determined and from the relation between the L-subshell intensities the multiplicities of the corresponding  $\gamma$ -transitions are derived. (auth)

## 17406

ENERGY SPECTRUM OF MESONS FROM NUCLEAR DISINTEGRATIONS PRODUCED BY 9 Bev PROTONS. Yu. T. Lukin, Zh. S. Takibaev, and E. V. Shalagina. Zhur. Eksptl. i Teoret. Fiz. **38**, 1074-7 (1960) Apr. (In Russian)

The energies of secondary shower particles from stars produced by 9 Bev protons in photographic emulsions were determined. The mean total energy of secondary  $\pi$ -mesons was found to equal  $(0.78 \pm 0.10)$  Bev and the mean transverse momentum  $(0.19 \pm 0.03)$  Bev/c. It is found that  $(40 \pm 5)\%$  of the primary proton energy is spent in meson production. (auth)

## 17407

THE  $Al^{27} \rightarrow Na^{24}$ ,  $Co^{59} \rightarrow Mn^{56}$ , AND  $P^{31} \rightarrow Na^{24}$  REACTIONS IN THE 260 Mev  $\gamma$ -QUANTUM ENERGY RANGE. A. N. Gorbunov, F. P. Denisov, and V. A. Kolotukhin. Zhur. Eksptl. i Teoret. Fiz. **38**, 1084-7 (1960) Apr. (In Russian)

The dependence of the yield of a number of photonuclear reactions on the peak bremsstrahlung energy from the synchrotron was measured by the induced radioactivity method. The differential cross sections were computed from the yield curves by the "photon difference" method. The shape of the energy dependence of the effective cross sections indicates that at photon energies above 60 to 80 Mev photonuclear reactions mainly proceed without the formation of an intermediate nucleus. (auth)

## 17408

INVESTIGATION OF THE DECAY SCHEME OF  $As^{76}$  BY THE  $\gamma$ -COINCIDENCE METHOD. N. N. Delyagin and A. A. Sorokin. Zhur. Eksptl. i Teoret. Fiz. **38**, 1106-10 (1960) Apr. (In Russian)

The decay scheme of  $As^{76}$  was investigated with a coincidence scintillation spectrometer. The following excited states of  $Se^{76}$  were found: 0.56, 1.21, 1.76, 2.42, 2.63, and  $\sim 2.85$  Mev. Thirteen  $\gamma$ -transitions between these levels were detected and their relative intensities determined. (auth)

## 17409

RESONANCE SCATTERING OF  $\gamma$ -QUANTA ON  $Se^{76}$  NUCLEI. N. N. Delyagin. Zhur. Eksptl. i Teoret. Fiz. **38**, 1111-14 (1960) Apr. (In Russian)

The lifetime of the first excited state of  $\text{Se}^{78}$  (0.56 Mev energy) was measured by the method of resonance scattering of  $\gamma$ -quanta by employing a gaseous  $\text{As}^{76}$  source in the form of  $\text{AsH}_3$ . The value  $(1.3 \pm 0.2) \cdot 10^{-11}$  sec was obtained for the lifetime. The absence of resonance scattering of 1.21 Mev  $\gamma$ -quanta corresponding to the transition from the second excited state of  $\text{Se}^{78}$  to the ground state indicates that the corresponding partial lifetime of the second excited state in  $\text{Se}^{78}$  is larger than  $6 \cdot 10^{-12}$  sec. (auth)

17410

FRAGMENT PRODUCTION BY 100 Mev PROTONS. U. R. Arifkhanov, M. M. Makarov, N. A. Perfilov, and V. P. Shamov. *Zhur. Eksptl'. i Teoret. Fiz.* 38, 1115-22(1960) Apr. (In Russian)

The formation of multicharged fragments of photographic emulsion nuclei by 100 Mev protons was investigated. The fragmentation cross section on heavy nuclei of the emulsion is  $(1.93 \pm 0.64)$  mb and  $(1.16 \pm 0.36)$  mb on light nuclei. Energy and angular characteristics of the process were obtained. Some arguments are presented which support the assumption that for  $E = 100$  Mev multicharged fragments are produced in quasielastic scattering of nucleon complexes of the nucleus. (auth)

17411

ON THE EXISTENCE OF NEW ISOTOPES OF LIGHT NUCLEI AND THE STATE EQUATION OF NEUTRONS. Ya. B. Zel'dovich. *Zhur. Eksptl'. i Teoret. Fiz.* 38, 1123-31(1960) Apr. (In Russian)

The limits of stability (relative to nucleon emission) of light nuclei are considered. The existence (in the sense of stability with respect to decay with nucleon emission) of the following nuclei is predicted:  $\text{He}^8$ ,  $\text{Be}^{12}$ ,  $\text{O}^{13}$ ,  $\text{B}^{15,17,19}$ ,  $\text{C}^{16-20}$ ,  $\text{N}^{18-20}$ , and  $\text{Mg}^{20}$ . The possible existence of heavy nuclei consisting of neutrons only is considered. This problem is reduced to that of a Fermi gas with resonance interaction of the particles. The energy of such a gas is proportional to  $\omega^{1/3}$  where  $\omega$  is its density. The accuracy of the calculations is not sufficient for determination of the sign of the energy and for solving the physical problem concerning neutron nuclei. (auth)

17412

SCATTERING OF ELECTRONS BY NUCLEI ACCORDING TO THE  $\alpha$ -PARTICLE MODEL. E. V. Inopin and B. I. Tishchenko. *Zhur. Eksptl'. i Teoret. Fiz.* 38, 1160-6(1960) Apr. (In Russian)

Elastic and inelastic (involving excitation of rotational levels) scattering of high-energy electrons by  $\text{Be}^9$ ,  $\text{C}^{12}$ , and  $\text{O}^{16}$  nuclei is considered on the basis of the  $\alpha$ -particle model. The calculated differential cross sections for elastic scattering on these nuclei and inelastic scattering with excitation of the 2.43 Mev and 6.8 Mev levels in the  $\text{Be}^9$  nucleus and 4.43 Mev level in the  $\text{C}^{12}$  nucleus are in good agreement with experiments. It is demonstrated that elastic scattering on  $\text{C}^{12}$  with excitation of the 9.61 Mev level can be explained within the framework of the model under consideration if one ascribes a spin and parity of  $3^-$  to this level. (auth)

17413

THEORY OF QUADRUPOLE RELAXATION OF NUCLEAR SPINS IN LIQUIDS. K. A. Valiev. *Zhur. Eksptl'. i Teoret. Fiz.* 38, 1222-32(1960) Apr. (In Russian)

Quadrupole relaxation of nuclear spins of diamagnetic atoms in liquids is treated theoretically. The calculations are carried out under the assumption that thermal motion of the liquid particles is a free translational diffusion.

This assumption is valid for metal and salt melts and for weakly solvated ions in electrolyte solutions. It is found that  $T_2^{-1} \sim \eta/T$  ( $\eta$  is the viscosity of the liquid) which is in good agreement with the measurements of  $T_2^{-1}$  for the  $I^{127}$  nuclear spin in aqueous solutions of  $\text{NaI}$  and  $\text{KI}$  salts. (auth)

17414

RENORMALIZATION IN PARITY NONCONSERVATION THEORY. B. L. Ioffe. *Zhur. Eksptl'. i Teoret. Fiz.* 38, 1263-75(1960) Apr. (In Russian)

A method is proposed for renormalization of mass, charge, and wave functions in the parity nonconservation theory. The method is checked in the case when the "three G-approximation" equation is employed for the vertex part. (auth)

17415

MOMENTS OF INERTIA OF ODD ATOMIC NUCLEI.

Yu. T. Green, S. I. Drozdov, and D. F. Zaretskii. *Zhur. Eksptl'. i Teoret. Fiz.* 38, 1297-1303(1960) Apr. (In Russian)

An expression is derived for the moment of inertia of odd nuclei, the effect of pair correlation being taken into account. The theory is compared with the experiments. (auth)

17416

ROTATIONAL ENERGY AND MOMENTS OF INERTIA OF NONAXIAL NUCLEI. A. S. Davydov, N. S. Rabotnov, and A. A. Chaban. *Zhur. Eksptl'. i Teoret. Fiz.* 38, 1311-15(1960) Apr. (In Russian)

It is shown that the dependence of the ratio of rotational energies of a nonaxial nucleus on the ratio of the energy of two rotational spin 2 states changes insignificantly when the nuclear moments of inertia deviate from their hydrodynamical values. (auth)

17417

ON THE EQUILIBRIUM SHAPE OF ATOMIC NUCLEI.

G. F. Filippov. *Zhur. Eksptl'. i Teoret. Fiz.* 38, 1316-19(1960) Apr. (In Russian)

The equilibrium shape of atomic nuclei was found for the case when the deformations are small and the external nucleons do not interact. (auth)

17418

SOME NEW ATOMIC MASS DETERMINATIONS MADE WITH A LARGE SINGLE-FOCUSING MASS SPECTROMETER. J. T. Kerr, G. R. Bainbridge, J. W. Dewdney, and H. E. Duckworth (McMaster Univ., Hamilton, Ont.). 9p. of "Advances in Mass Spectrometry." New York, Pergamon Press, 1959. (AFOSR-TN-59-618) and (AD-217405).

A large semi-circular magnetic analyzer with a resolving power (at the base of the peaks) of  $\sim 9000$  was used to determine the atomic masses of  $\text{Kr}^{84}$ ,  $\text{Kr}^{86}$ ,  $\text{Xe}^{128}$ ,  $\text{Xe}^{132}$ ,  $\text{Hg}^{200}$ ,  $\text{He}^{201}$ , and  $\text{Hg}^{204}$  to a precision of  $\sim 1/2,000,000$ . The necessary doublet spacings were determined by a beam modulation technique. This technique and certain other details of the apparatus are described. (auth)

## Particle Accelerators

17419 ML-634

Stanford Univ., Calif. Microwave Lab.

RADIATION FROM RELATIVISTIC ELECTRONS. Quarterly Progress Report No. 12 [for] March 15-June 15, 1959. Kenneth B. Mallory and H. John Shaw. Aug. 1959. 16p. DA Project No. 3-99-13-022. Contract DA-36-039 SC-72785.

An improved accelerator waveguide was fabricated; final design predicts bunches of 0.5 degree in length. In continuing tests on the  $\frac{5}{8}$ -inch-diameter cavity, it was found that moving the coupling hole significantly changed the resonant frequency of the cavity and resulted in detuning. A compact grating spectrometer was built. Successful operation of a form of ferromagnetic microwave generator was obtained on an initial experimental model. Radio-frequency pulse widths up to approximately 30 msec were observed with single crystal materials. (For preceding period see ML-594.) (C.J.G.)

**17420 MURA-559**

Midwestern Universities Research Assn., Madison, Wis. ELECTRON MODEL OF A SPIRAL SECTOR ACCELERATOR. D. W. Kerst, E. A. Day, H. J. Hausman, R. O. Haxby, L. J. Laslett, F. E. Mills, T. Okawa, F. L. Peterson, E. M. Rowe, A. M. Sessler, J. N. Snyder, and W. A. Wallenmeyer. [1960]. 135p. OTS.

A six-sector spiral ridge FFAG accelerator was constructed and successfully operated to accelerate electrons from 35 to 180 kev kinetic energy. Acceleration was by betatron action, supplemented by r-f acceleration when desired. The design was based on magnetostatic and orbit computations performed with the Illiac digital computer. Subsequent performance was found to be in good accord with these computations. Tuning coils permitted variation of the basic parameters about the design values suggested by the computations. The theoretical basis of the computational work, the constructional features of the accelerator, and the magnetostatic measurements are described. Tests with an operating model are reported, comprising a resonance survey, injection studies, perturbation studies, and the use of r-f acceleration. The frequencies of radial and axial betatron oscillation at the nominal operating point were  $\nu_x = 1.40$  and  $\nu_y = 1.12$ , respectively. The resonance survey indicated this operating point to be centrally located within a region of relatively large intensity which was bounded by the resonances  $\nu_y = 1.0$ ,  $\nu_x = 1.5$ , and (less markedly)  $2\nu_y - \nu_x = 1$ . Injection from a deflector-structure with a thin septum permitted efficient injection to be achieved either by concomitant rapid acceleration of the injected electrons or, alternatively, by use of a time-dependent radial electric field applied as a perturbation. Experiments with a protracted injection pulse permitted the observation of phenomena attributable to space-charge effects. A suitable frequency-modulation schedule permitted successful acceleration of a substantial fraction of stacked electrons through the transition energy. A modulator, with negative-feedback stabilization, which permits protracted injection is described. The principles of Parzen's theory of perturbations, which was found to account satisfactorily for the results of the perturbation experiments, are discussed. (auth)

**17421 MURA-561**

Midwestern Universities Research Assn., Madison, Wis. COMPUTATIONAL RESULTS PERTAINING TO USE OF A TIME-DEPENDENT MAGNETIC FIELD PERTURBATION TO IMPLEMENT INJECTION OR EXTRACTION IN A FFAG SYNCHROTRON BY USE OF THE  $\nu_r = N/3$  RESONANCE. L. J. Laslett and K. R. Symon. Mar. 7, 1960. 71p. Contract AT(11-1)-384. OTS.

The use of the  $\nu_r = N/3$  resonance to implement injection (or extraction) in a FFAG accelerator is examined and computational examples of some of the expected performance features are presented. The field of the accelerator is considered to be perturbed by a "field bump," whose period is equal to three periods of the basic (unperturbed) magnet structure, so that the

radial oscillations represented by particle trajectories with amplitudes near the stability limit undergo a phase change of substantially  $2\pi/3$  in passing through one sector of the unperturbed machine and a change of  $2\pi$  in the basic period of the perturbed accelerator. It is shown that the boundary of the stable area in radial phase space, which normally is roughly triangular in the unperturbed accelerator, can be opened up at one of the vertices of this separatrix by a suitably phased perturbation of the type described and that through the fixed point in this region of the diagram a new, modified separatrix will pass to enclose the stable phase area of the perturbed accelerator. Particles injected so that the initial portions of their phase trajectories pass around this latter phase area will be captured, with full phase density, as the perturbation is decreased (ultimately to zero) and as the stable phase area, in consequence, becomes enlarged. It is seen that injection with full phase density may be expected if the injector at all times covers the entire region of phase space from which particles must originate in order to surround the growing phase area of the accelerator. Computational examples, with simplified equations of motion, show that the region which thus must be covered by the injector can be that enclosed by a boundary of rather simple shape, and is substantially free of filamentation, if injection occurs every three sectors (as in a three-sector accelerator). It also is found, however, that the requisite phase area to be covered by the injector becomes quite tortuous if transformed through an additional three sectors, as would be required to define the area needed with six-sector injection. The inclusion of axial motion in the computational examples showed that an orderly, efficient transfer of phase volume into the stable region of the unperturbed accelerator could be achieved by this method with three-sector injection and that the phase region which then should be covered by the injector again was enclosed by a simple boundary. Examples are given of phase curves which are similar in their essential topological features to those used in the aforementioned study but which represent the dynamics of radial motion in a spirally-ridged FFAG accelerator, the field-modification which was applied as a perturbation in this case being taken, for convenience, as an additional scaling field which follows the same logarithmically-spiralling pattern as that characterizing the unperturbed accelerator. (auth)

**17422 MURA-568**

Midwestern Universities Research Assn., Madison, Wis. ALTERNATIVE FORMULATIONS OF MAGNETOSTATIC PROBLEMS. R. S. Christian and S. C. Snowdon. Apr. 11, 1960. 13p. Contract AT(11-1)-384. OTS.

It is shown that the magnetostatic problem in the presence of distributed currents can be formulated in terms of a scalar boundary value problem in which solutions of Laplace's equation are found that conform to prescribed single and double layer distributions at the copper-air and the copper-iron interfaces. It is shown that the prescribed discontinuities are not unique and may be modified to yield a variety of solutions to the potential problem. These formulations have no effect on the magnetic fields but do permit in some cases a simplification of the potential problem. Application is made to the case of a scaling spiral sector FFAG guide field. (auth)

**17423 PLAC-10**

United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England.

## PROTON LINEAR ACCELERATOR TANKS 2 AND 3: DESIGN NOTES AND DATA. J. J. Wilkins. Mar. 1955. 11p.

The derivation of the design of tanks 2 and 3 (10 to 50 Mev) of the Harwell proton linear accelerator is sketched. Data on dimensions, predicted r-f field distributions, power losses, Q values, etc., are given. (auth)

## 17424 UCRL-9103

California. Univ., Berkeley. Lawrence Radiation Lab. LINAC INJECTION FOR THE 340-MEV BERKELEY ELECTRON SYNCHROTRON: PART II—EXPERIMENTAL. K. C. Crebbin and W. L. Everette. Feb. 1960. 22p. Contract W-7405-eng-48. OTS.

The problems of linac injection into the Berkeley synchrotron are considered. Original inflector design and its modification, beam alignment, and preliminary results are covered. At the end of the testing, beam was carried around one turn but no indication of beam pickup and acceleration by the r-f was found. (auth)

## 17425 AEC-tr-4091

THE INFLUENCE OF SPACE CHARGE ON THE MOTION OF PARTICLES IN ACCELERATORS. V. I. Kotov and V. A. Pushtarik. Translated by Igor N. Sviatoslavsky from Atomnaya Energ. 7, 268-72(1959). 8p. JCL or LC.

This paper was previously abstracted from the original language and appears in NSA, Vol. 14, as abstract No. 2077.

## 17426 AEC-tr-4094

PLANNING AND PRELIMINARY RESEARCH FOR THE KARLSRUHE RELATIVISTIC ISOCHRONOUS CYCLOTRON. K. Steimel and A. Lerbs. Translated from Atomwirtschaft 4, 345-8(1959). 16p. JCL.

This paper was previously abstracted from the original language and appears in NSA, Vol. 13, as abstract No. 22543.

## 17427

A 600 KEV PROTON INJECTOR FOR A LINEAR ACCELERATOR. Yu. N. Antonov, L. P. Zinov'ev, and V. P. Rashevskii. Atomnaya Energ. 8, 454-7(1960) May. (In Russian)

Descriptions are given of an ion source for a 600-kev proton injector for use with a 10-Bev synchrophasotron. The dimensions and angular divergence of the beam at the tube outlet were designed for linear accelerator injection. The incandescence potential is 7.8 v, incandescence current 6.4 a, arc intensity 90 to 120 v, arc current 30 a, magnetic field in the gap 1000 gauss, discharge chamber gas pressure  $1.5 \times 10^{-2}$  mm mercury, gas consumption  $150 \text{ cm}^3/\text{h}$ , and the proton component of the current is 75%. The tube clearance diameter (for 600 kev) is 350 mm and the length 1670 mm. The scheme of the power supply and focusing electrodes is included. (R.V.J.)

## 17428

ACCELERATION OF ELECTRONS IN A CYCLIC TRAVELLING-WAVE ACCELERATOR. A. A. Vorob'ev, A. N. Didenko, and E. S. Kovalenko. Atomnaya Energ. 8, 459-61(1960) May. (In Russian)

A section of a curved waveguide, with a propagating wave  $\phi$  component different from zero, was analyzed in order to determine the self-wave field control of the particle trajectory. The phase wave velocity near the mean radius is  $v_{\text{phase}} = c$ . The derived formulas show that curved waveguides decrease the phase velocity of synchronizing waves and influence their dispersion. It is also shown that with acceptable waveguide dimensions it is possible to attain  $v_{\text{phase}} = c$  propagation in the mean radius region in cases where parasitic waves are absent

and the resistance is several ohms. The analysis indicates that waveguide particle dynamics is similar to synchrotron particle dynamics, and that the complex configuration of the wave field does not interfere with normal acceleration. (R.V.J.)

## 17429

CSIR CYCLOTRON IN PROGRESS. J. J. Burgerjon (National Physical Research Lab., Pretoria). Ind. Rev. Africa. Suppl. Atomics and Energy 11, No. 8, 79-84(1960) Feb.

The CSIR cyclotron which gives off an internal 16-Mev deuteron beam is discussed together with some of the principles of cyclotrons with fixed and modulated frequency and azimuthally varying field. The scheme of the CSIR cyclotron is outlined; extraction and deflection of the internal beam are explained in detail. Data on the dimensions are given and comparisons with other cyclotrons are made. (D.L.C.)

## 17430

4 KW IN A BEAM. D. F. Rex (Diamond Research Lab., Johannesburg). Ind. Rev. Africa. Suppl. Atomics and Energy 11, No. 9, 120-3(1960) Mar. (In English)

A 4-kw electron accelerator of the Cockcroft-Walton type used in the Diamond Research Laboratory in South Africa is described. The high voltage generator and accelerator tube are operated under 11 atmospheres of nitrogen. The system is arranged so that the tungsten filament can be replaced while still under vacuum and inaccessible electrical circuits can be monitored by television cameras. (D.L.C.)

## 17431

PENDULUM ANALOGUES TO ILLUSTRATE THE PARTICLE MOTION IN SPIRAL RIDGE ACCELERATORS. J. D. Lawson, D. H. Lord, and F. M. Russell (Atomic Energy Research Establishment, Harwell, Berks, Eng.). J. Nuclear Energy, Pt. C. Plasma Phys.-Accelerators-Thermonuclear Research 1, 124-9(1960) Mar.

The essential features of the motion of a particle in an azimuthally varying magnetic field of "spiral ridge" form may be described by a pair of non-linear coupled equations of simple form. These reduce to the uncoupled linear radial and vertical betatron equations when the azimuthally varying component of field is zero. Two pendulum analogs are described, which obey the same equations of motion as the particles. The first of these represents the radial motion only and consists of a torsional pendulum with a magnetic moment which interacts with a rotating magnetic field; the second, which represents both radial and vertical motion, consists of a compound pendulum supported by two sets of pivots at right angles, with a magnetic bob which interacts with a traveling magnetic field. The first of these analogs was used to make an extensive survey of the maximum stable amplitude of the motion as the parameters corresponding to ridge angle, azimuthal field modulation depth and radial field index were varied. No quantitative measurement was made with the second model, but the effect of ridges in stabilizing the vertical motion was demonstrated. (auth)

## 17432

THE INJECTOR FOR THE HARWELL PROTON LINEAR ACCELERATOR. L. C. W. Hobbis, E. R. Harrison, and H. C. Whitby (Atomic Energy Research Establishment, Harwell, Berks, Eng.). J. Nuclear Energy, Pt. C. Plasma Phys.-Accelerators-Thermonuclear Research 1, 130-4(1960) Mar.

The injector is a d-c accelerator delivering a pulse proton beam of 15 ma at an energy of 515 kev. The installation

is described and details are given of its most important features. (auth)

**17433**

EXPERIMENTAL STUDY OF THE OPERATION OF THE INJECTOR IN A BETATRON. V. N. Logunov, E. P. Ovchinnikov (Ovcinnikov), and V. D. Rusanov. *Kernenergie* 1, 273-8 (1958) Apr. (In German)

Experiments are described which were performed on the synchrotron of the Phys. Inst. Acad. Science USSR (electron energy, 30 Mev) in order to explain the physical and mathematical interrelationships of the phenomenon of electron capture in betatron operation of accelerators. The effects of alternating magnetic and electric fields which are produced artificially inside the acceleration chamber at the moment of electron injection on the operation of the injector are examined. It is shown, however, that like an additional magnetic field, the effect of which can be compared with the action of an electric eddy field on a particle (Kerst hypothesis), the space-charge field can strongly increase the intensity of  $\gamma$  rays at small emission currents. Of course this allows evaluation of the conclusion that the compression induced according to the Kerst hypothesis should be small compared to Coulomb interactions in normal operation of the betatron. It is further shown that generally analogous artificial methods of increasing intensity are not effective. At the beginning it was demonstrated that only the methods which permit a substantial change in the stabilizing power of the magnetic can lead to considerable increases in output since most betatrons operate at the "highest current" working conditions. (tr-auth)

**17434**

LINEAR-CYCLIC ACCELERATOR. D. M. Zorin, O. S. Milovanov, and A. V. Shal'nov (Sal'nov). *Kernenergie* 1, 301-2 (1958) Apr. (In German)

A modification of the linear-cyclic accelerator or Elutron is offered. The Elutron is made up of two linear accelerators, a magnetic mirror system, and a relativistic electron injector. The magnet system has 4 mirrors each of which inverts the beam 90°. A homogeneous static magnetic field acts at right angles to the orbital plane so that the particle orbits are deflected in the direction of the edge of the magnetic mirrors at a 45° angle. A second analogous magnetic mirror system is proposed to force particles of different energies to move in closed orbits along the axes of the common orbit segments of the linear accelerators. Thus, to accelerate particles of different energies, the accelerating wave must equal the velocity of light. In using this scheme, the relation between the oscillating frequency of the high-frequency generators which feed the linear accelerators and the time for motion of the particle in the orbit must be established. (T.R.H.)

**17435**

France. Commissariat à l'Énergie Atomique. Centre d'Etudes Nucléaires, Saclay.

RADIATION CONTROL AT THE SACLAY PROTON SYNCHROTRON. H. Joffre, P. Candes, and A. Stirling. p.271-83 of "Health Physics in Nuclear Installations Symposium, Risø, May 25-28, 1959." (In French)

After a summary description of the characteristics of the Saclay Proton Synchrotron, its safety features are described. The accelerator itself is shielded by 3 m of dense (half 3.6 and half 4.8) concrete and the walls of the accelerator hall have another 2 m. The radiation detection and alarm systems are relatively complex, as dictated by the presence of high-energy radiation. When beam intensity is increased, the shielding thicknesses will have to be increased. (T.R.H.)

## Plasma Physics and Thermonuclear Processes

**17436** TID-7558(Suppl. 1)

Division of Research. Controlled Thermonuclear Branch, AEC.

PAPERS PRESENTED AT THE CONTROLLED THERMONUCLEAR CONFERENCE HELD AT WASHINGTON, D. C., FEBRUARY 3-5, 1958. May 1960. 34p. OTS.

Four previously classified papers are given which were presented at the Washington Conference on Controlled Thermonuclear Reactions. Separate abstracts were prepared for the four papers. (W.D.M.)

**17437** TID-7558(Suppl. 1)(p.1-4)

California. Univ., Livermore. Lawrence Radiation Lab. GENERAL REVIEW OF THE ASTRON THERMONUCLEAR PROGRAM. N. C. Christofilos. p.1-4 of PAPERS PRESENTED AT THE CONTROLLED THERMONUCLEAR CONFERENCE HELD AT WASHINGTON, D. C., FEBRUARY 3-5, 1958.

The Astron program was initiated at Livermore in 1957. The first object of the program is the design and construction of a model to test the Astron concept. The basic features of the Astron concept are described. (auth)

**17438** TID-7558(Suppl. 1)(p.5-9)

California. Univ., Livermore. Lawrence Radiation Lab. INJECTION OF ELECTRONS INTO THE ASTRON REACTOR. N. C. Christofilos. p.5-9 of PAPERS PRESENTED AT THE CONTROLLED THERMONUCLEAR CONFERENCE HELD AT WASHINGTON, D. C., FEBRUARY 3-5, 1958.

The injection of the E-layer electrons into the Astron reactor is described by following the electrons as they emerge from the anode of the 1-Mev electron gun through the various steps up to their injection in the reactor volume. Several problems are imposed by this injection process and their solutions are discussed briefly. (auth)

**17439** TID-7558(Suppl. 1)(p.10-17)

California. Univ., Livermore. Lawrence Radiation Lab. GENERAL PARAMETERS FOR A 500-MW ASTRON POWER REACTOR. N. C. Christofilos. p.10-17 of PAPERS PRESENTED AT THE CONTROLLED THERMONUCLEAR CONFERENCE HELD AT WASHINGTON, D. C., FEBRUARY 3-5, 1958.

The basic plasma parameters of a 500-Mw Astron power reactor are derived. The influence of the diffusion and charge exchange losses in the determination of the plasma parameters is discussed. A new method of fuel injection is proposed; namely, to use as fuel heavy tritiated and deuterated hydrocarbon molecules of molecular weight 100, approximately, and to inject these molecules as ions, singly ionized and accelerated up to 1000 volts per nucleon. (auth)

**17440** TID-7558(Suppl. 1)(p.18-30)

California. Univ., Livermore. Lawrence Radiation Lab. ENGINEERING STUDY OF AN ASTRON POWER REACTOR. N. C. Christofilos, N. W. Cook, W. B. Myers, C. E. Taylor, and W. M. Wells. p.18-30 of PAPERS PRESENTED AT THE CONTROLLED THERMONUCLEAR CONFERENCE HELD AT WASHINGTON, D. C., FEBRUARY 3-5, 1958.

A plasma of deuterium-tritium confined in the steady state by an Astron machine is taken as an energy source for the production of commercial electric power. Components of the conversion system are considered and a particular self-consistent arrangement is described. (auth)

**17441** UCRL-5696

California. Univ., Livermore. Lawrence Radiation Lab. CONFINEMENT TIME OF A LORENTZIAN GAS IN A MIR-

ROR MACHINE. Gordon Gibson and Eugene J. Lauer. Nov. 1959. 25p. Contract W-7405-eng-48. OTS.

The model which has been studied assumes an isotropic uniform volume source of monoenergetic charged particles which behave adiabatically in a uniform field and for which there exists sinks, corresponding to the loss cones, in velocity space. Information of the containment time is obtained from approximate analytical solutions to the Boltzmann equation with the condition that small-angle multiple Coulomb gas scattering is the dominant loss mechanism (i.e., the Fokker-Planck approximation). The fundamental containment time,  $\tau_i$ , (e-fold time of the decay of the charged particle density after a time of order  $\tau_i$  subsequent to removing the source) is found to be consistent with the time predicted by a multiple scattering formula for the root mean square angle of deflection of an electron in passing through a foil, if  $\pi/2$  minus the half-angle defining the loss cone is substituted for the projected root mean square angle. Some preliminary measurements of this containment time which have been made in the " $\beta^+$  ray" experiment are mentioned which indicate satisfactory agreement. (auth)

17442 UCRL-5911-T

California. Univ., Livermore. Lawrence Radiation Lab. A PLASMA CYCLOTRON. H. P. Furth. Apr. 6, 1960. 6p. OTS.

A plasma cyclotron machine suitable for the production of hot ions is discussed and rough sketches are given. (W.D.M.)

17443

FOURIER ANALYSIS OF THE ELECTRICAL MICROFIELD IN A PLASMA. [PART] II. G. Hettner and H. Wagner (Technische Hochschule, Munich). *Ann. Physik* 7, 405-13 (1960). (In German)

In a previous report (*Ann. Physik* (7)4, 89(1959)) a Fourier analysis of the temporal pattern of the components of the electrical microfield in a plasma was made. Aside from the Coulomb interaction of the charged particles of the plasma, their motion was considered both homogeneous and rectilinear. Since this assumption is no longer permissible at high densities of charged particles, the effect of the strongly curved part of the electron orbit was investigated by the frequency spectrum. It is shown that this orbit fraction principally gives contributions at the highest frequencies. For the probability of the Fourier amplitudes of the field intensity, a Gaussian distribution is given which for high frequencies is displaced toward higher amplitudes. (tr-auth)

17444

CONFINEMENT AND ENERGY BALANCE IN A ROTATING PLASMA. B. Lehnert (Royal Inst. of Tech., Stockholm). *Arkiv Fysik* 17, 177-8 (1960). (In English)

In order to describe completely the plasma confined by a magnetic field of a current loop, the relation between the centrifugal force and the thermal energy has to be deduced from the energy balance. For an axially symmetric plasma whose angular velocity is constant along the magnetic field lines, two cases can be treated, namely plasmas with zero and infinite thermal conductivity along the lines; the latter is more likely to prevail. Neglecting charge exchange, the equation for the density distribution is  $\rho/\rho_0 = \exp[-5(r_0^2 - r^2)/2r_0^2]$ , where  $\rho$  is the density at a  $(r, \phi, z)$  point in a cylindrical coordinate system,  $r_0$  refers to the circle of intersection of the toroidal surface and the equatorial plane, and  $r_0$  is the radius at which the toroidal surface meets the vessel wall. The above equation is in some ways analo-

gous to the barometric equation, with the centrifugal field substituted for the gravitational field. It should be applicable up to  $10^7$  K, above which confinement is affected by charge exchange and scattering of neutral particles, but the energy loss should be less in the field of a current loop than in homopolar machines. The disagreement between theory and experiment in the case of instabilities is discussed. (D.L.C.)

17445

INSTRUMENTATION FOR PLASMA PROPULSION. J. J. Pearson (Republic Aviation Corp., Farmingdale, N. Y.). *Electronics* 33, No. 24, 66-9 (1960) June 10.

The linear pinch effect in plasmas and its application in Republic Aviation's propulsion system are described. In the system, the linear pinch electrodes are designed so that the pinch, instead of closing in on itself, is directed through an opening in one of the electrodes, producing a thrust. Its feasibility for space propulsion is shown by the fact that an experimental engine has run for periods of more than 100 hours with no trouble and little or no electrode erosion. Instrumentation is necessary for the study of thrust, temperature, etc., and for this purpose, a high-speed streak camera system was developed. A diametrical slit of 0.05-inch width in the upper electrode and covered with a glass gives an axial view of the pinch chamber, and by means of a system of mirrors and lenses, this view is projected onto a strip of movie film on the inside surface of a drum rotating at 500 rps. A photograph of a pinch obtained in this manner is given together with the wave form of the current; a series of pinches is shown, each pinch roughly coinciding with each rise in the current. The circuitry and behavior of flash tubes for timing marks are described. (D.L.C.)

17446

RUNAWAY AND SUPRATHERMAL PARTICLES. E. R. Harrison (Atomic Energy Research Establishment, Harwell, Berks, Eng.). *J. Nuclear Energy, Pt. C. Plasma Phys.-Accelerators-Thermonuclear Research* 1, 105-15 (1960) Mar.

Under certain conditions an electron or ion is accelerated continuously when subject to a force greater than the dynamic friction; as a result it is decoupled from its thermal state of motion and is said to be "runaway." Runaway particles lead to, and form part of, a class of particles which have been referred to elsewhere as "suprothermal." The study of the way in which runaway particles are produced and accelerated is not only of importance in laboratory gas discharges, but also in a wide variety of applications in astrophysics. The subject of runaway electrons and ions is treated, first in a uniform ionized gas in which the particles have Maxwellian velocity distributions and, secondly, in a current conducting plasma. The conditions for decoupling and accelerating particles from their thermal state are discussed and, in particular, it is shown that in the case of a weak electric field ions are unlikely to achieve speeds very much in excess of the drift speed of the electrons, except in restricted regions where runaway electrons are continually forming and escaping. When the ratio of the thermal and magnetic energy densities, given approximately by  $\beta$ , is small, the runaway electron current grows rapidly at the expense of the conducting current. A number of ways are considered in which the runaway current may grow and become predominant. Finally, the generation of suprothermal ions by Fermi interactions is considered, from which it is evident that when  $\beta$  is the order of unity the ion gas is heated and when  $\beta$  is small relatively few ions are accelerated to high energies. (auth)

## 17447

EXPERIMENTS WITH PLASMA RINGS. H. Alfvén, L. Lindberg, and P. Mitlid (Royal Inst. of Tech., Stockholm). J. Nuclear Energy, Pt. C. Plasma Phys.-Accelerators-Thermonuclear Research 1, 116-20(1960) Mar.

The construction of a coaxial plasma gun is described. At its output end the gun is provided with a radial magnetic field, which is trapped by the plasma. The plasma from the gun is studied by photographic and magnetic methods. It is demonstrated that the gun produces magnetized plasma rings with the same basic structure as the rings obtained in toroidal pinch experiments. When the plasma rings are formed, the magnetic field lines from the gun break, a result which is of interest from a theoretical point of view. (auth)

## 17448

A LIQUID CONDUCTOR MODEL OF THE HOLLOW PINCH. B. Lehnert and G. Sjögren (Royal Inst. of Tech., Stockholm). J. Nuclear Energy, Pt. C. Plasma Phys.-Accelerators-Thermonuclear Research 1, 121-3(1960) Mar.

Electric current is sent through a hollow jet of mercury which is flowing over the surface of a glass tube. The jet is broken up by the action of the electrodynamic force. However, if at the same time a strong current is sent through a central conductor placed inside the glass tube, the jet can be stabilized. This occurs when the currents are parallel. Sausage instabilities have not been observed in the present experiment. (auth)

## 17449

THE ABSORPTION COEFFICIENT OF A PLASMA AT RADIO FREQUENCIES. P. A. G. Scheuer (Cavendish Lab., Cambridge, Eng.). Monthly Notices Roy. Astron. Soc. 120, 231-41(1960).

The theory of radiation due to free-free transitions by electrons in a plasma has been the subject of much work. Elwert has given an exact theory for binary electron-ion encounters but there has been doubt about the applicability of the formulae when an electron moves in the field of many ions at comparable distances; it is intended to remove that doubt. The power radiated by an electron at frequency  $\nu$  is proportional to the mean square amplitude of the Fourier component of frequency  $\nu$  of its acceleration; as Cohen, Spitzer and Routly have pointed out in a different context, one obtains the correct value of this mean square amplitude by treating all encounters as independent binary encounters, provided that the collision parameters concerned are all less than the Debye length. In the radiation problem, one is only interested in frequencies greater than the plasma frequency, and the binary collisions contributing to such radiation all have collision parameters less than the Debye length. Consequently Elwert's treatment always gives the correct result, except at frequencies just above the plasma frequency. An explicit formula for the absorption coefficient of a plasma is worked out for a Maxwellian distribution of electron speeds. The earlier considerations are applied to find the conditions necessary for radio-frequency radiation from encounters between electrons and concentrations of space charge. (auth)

## 17450

RADIO EMISSION FROM PLASMA SHOCKS. E. N. Parker and D. A. Tidman (Univ. of Chicago). Phys. Fluids 3, 389-72(1960) May-June.

From recent calculations of the efficiency of r-f emis-

sion from longitudinal plasma oscillations, and from simple considerations of charge separation in collisionless plasma shocks, it is shown that one can predict a quantitative value for the energy of a type II solar radio burst in agreement with observation. Application of the same methods to the solar corona suggests that the radio spectrum of the quiet sun may be nonthermal below 20 Mc, and that the solar wind may generate at earth as much as a megawatt of power at 1 Mc. (auth)

## 17451

MAGNETOHYDRODYNAMIC WAVE PROPAGATION IN THE IONOSPHERE. Sheldon L. Kahalas (Allied Research Associates Inc., Boston). Phys. Fluids 3, 372-8(1960) May-June.

The propagation of magnetohydrodynamic waves in a compressible fluid is discussed with reference to the ionosphere. An investigation of the damping for a gas of finite conductivity shows that different wave modes may be heavily attenuated in certain directions of propagation. Also, the slow wave of the magneto-acoustic mode is shown to exhibit preferentially less damping for propagation along the magnetic field lines. An examination of the Hall and electron pressure terms shows that they may be neglected for low enough wave frequencies. The coupling of electromagnetic to magnetohydrodynamic waves at a plasma-vacuum boundary is considered. The coupling coefficient is estimated to be one percent. (auth)

## 17452

HYDRODYNAMIC MODEL OF DIFFUSION EFFECTS ON SHOCK STRUCTURE IN A PLASMA. O. W. Greenberg and H. K. Sen (Air Force Cambridge Research Center, Bedford, Mass.) and Y. M. Tréve (Block Associates, Inc., Cambridge, Mass.). Phys. Fluids 3, 379-86(1960) May-June.

Diffusion effects on the structure of a steady, plane shock in a proton-electron plasma were studied using a simplified, two-fluid, hydrodynamic model in which diffusion is the only shock broadening mechanism. Charge separations occur inside the shock because of the mass difference between protons and electrons. The shock is shown to have electric field and density oscillations as a function of distance through the shock. The peak electric fields are large; the peak electric field inside a weak shock of Mach 1.169 reaches 41,700 v/cm for typical quiescent plasma conditions. The distance in which electric field changes occurs is of the order of ten Debye lengths of the quiescent plasma. (auth)

## 17453

BOUNDARY-LAYER FORMATION IN THE PINCH. John Killeen, Gordon Gibson, and S. A. Colgate (Univ. of California, Livermore). Phys. Fluids 3, 387-94(1960) May-June.

A study is made of various processes that occur prior to the pinch effect when an electric field is applied to a deuterium gas. The variables of the problem are the percentage of ionization, the electron and ion temperatures, the resistivity of the gas, and the current density. A one-dimensional problem is considered in which the above variables are determined as functions of one-space dimension and the time. The equations determining these variables are: the heat developed as the current flows through the gas equals the rate of increase of the internal energy of the plasma, the equation describing the rate of ionization, the equation describing the rate of transfer of energy from electrons to ions, and the electromagnetic field equations. These equations are a generalization of

the plasma equations solved by Wyld and Watson in that spatial dependence is included, i.e., a current layer is calculated instead of assuming a constant current. The equations are solved numerically using an IBM 704 computer. (auth)

17454

ON RAYLEIGH'S PROBLEM IN MAGNETOHYDRODYNAMICS. Vernon J. Rossow (National Aeronautics and Space Administration, Moffett Field, Calif.). *Phys. Fluids* 3, 395-8(1960) May-June.

A comparison is made of three flow fields that may be described as Rayleigh's problem in magnetohydrodynamics and that differ only in the state of motion of the magnetic field. Deviations of approximate expressions for the velocity from the more exact relations are also presented when the ratio of the viscous and magnetic Reynolds numbers is unity. (auth)

17455

OSCILLATIONS OF A NONUNIFORM PLASMA. Erich S. Weibel (Space Technology Labs., Inc., Los Angeles). *Phys. Fluids* 3, 399-407(1960) May-June.

The oscillations of a plasma which is confined by an r-field are investigated. The confining potential is approximated as  $\psi(x) = \frac{1}{2}m\omega_0^2x^2$ . Longitudinal plasma oscillations in the x direction are determined from the self-consistent Boltzmann transport equation without the collision term (Vlasov equation). This equation is linearized about equilibrium velocity distribution  $f_0 = \exp[-(\psi + \frac{1}{2}mv^2)/kT]$ . By expanding the electric field in Hermite polynomials, it is possible to reduce exactly the resulting integro-differential equation to an infinite system of linear equations for the expansion coefficients. The resonant frequencies are the roots of the determinant of the system. The frequency spectrum so obtained is quite unlike those obtained for Sturm-Liouville problems. This spectrum contains the integral multiples of  $\omega_0$  as limit points. As  $e^2n/m\omega_0^2 \rightarrow 0$ , the resonant frequencies coalesce into these limit points, each of these frequencies  $\mu\omega_0$  ( $\mu$  = integer) being infinitely degenerate. Since all frequencies are real, the oscillations are not damped. The resonant frequencies are determined approximately as functions of  $e^2n/m\omega_0^2$  as the roots of principal sub-determinants of finite order N. This procedure converges rapidly with increasing N. (auth)

17456

SCATTERING OF ELECTROMAGNETIC WAVES BY LONGITUDINAL PLASMA WAVES. Philip Rosen (Yale Univ., New Haven and Univ. of Massachusetts, Amherst). *Phys. Fluids* 3, 416-17(1960) May-June.

It is shown that Bragg reflection of electromagnetic waves from plasma oscillations is possible. The wave equation for the electromagnetic field passing through a medium of plasma waves is derived, and it is found to be similar to that of Brillouin for a wave in a medium of variable dielectric constant. (auth)

17457

RESONANCE IN A PLASMA WITH TWO ION SPECIES. S. J. Buchsbaum (Bell Telephone Labs., Inc., Murray Hill, N. J.). *Phys. Fluids* 3, 418-20(1960) May-June.

When a high-density plasma column in an axial magnetic field possesses two (or more) ion species of different charge-to-mass ratios, there exists a plasma resonance condition which involves only the ion cyclotron frequencies. At resonance, the two ion clouds oscillate transversely to the static magnetic field and 180° out of phase with each other, while the electrons remain relatively motionless. The ratio of the ion oscillatory energy to that of the elec-

trons is of the order of the ratio of the ion-to-electron masses. Collisions between the two ion clouds randomize the large ordered velocities of the ions with great efficiency. Thus, by exciting this resonance, considerable ion heating may be realized. The effect of varying the relative concentration of the two ions is discussed. (auth)

17458

LOSS OF CHARGED PARTICLES IN A STELLARATOR DURING OHMIC HEATING. R. A. Ellis, Jr., L. P. Goldberg, and J. G. Gorman (Princeton Univ., N. J.). *Phys. Fluids* 3, 468-73(1960) May-June.

The average charged particle confinement times  $\tau_0$  in hydrogen and deuterium plasmas during ohmic heating in the B-3 stellarator were determined. The observed values of  $\tau_0$  are approximately proportional to the square root of the magnetic confining field and were less than the values expected on the basis of classical collisional diffusion. The low values of  $\tau_0$  persisted when the system was, in theory, made hydromagnetically stable by the addition of helical stabilizing winding. It is inferred that the observed low confinement times are not due to a known hydromagnetic instability. (auth)

17459

OBSERVATION OF APPARENT FLUTE-TYPE PLASMA INSTABILITY. Hillman Dickinson (U. S. Military Academy, West Point, N. Y. and Stevens Inst. of Tech., Hoboken, N. J.); and Winston H. Bostick, Joseph N. DiMarco, and Samuel Koslov (Stevens Inst. of Tech., Hoboken, N. J.). *Phys. Fluids* 3, 480-1(1960) May-June.

This flute-type instability has been photographed with a Kerr cell shutter at 0.4  $\mu$ sec exposure. It is analogous to the Rayleigh-Taylor instability which occurs at the boundary between accelerated heavy and light fluids. For this instability, the fluids are replaced by the plasma projected by the gun and magnetic field, respectively. Experimental observations are discussed. (B.O.G.)

17460

VIRIAL THEOREM FOR PLASMAS. George Schmidt (Stevens Inst. of Tech., Hoboken, N. J.). *Phys. Fluids* 3, 481-2(1960) May-June.

A generalization of the Chandrasekhar-Fermi virial theorem is outlined to include plasmas. From this generalization it may be concluded that in the absence of confining gravitational fields, self-confinement of plasmas cannot be achieved. (B.O.G.)

17461

PARTITION OF ENERGY IN A PULSED PLASMA ACCELERATOR. William J. Guman (Republic Aviation Corp., Farmingdale, N. Y.). *Phys. Fluids* 3, 483-4(1960) May-June.

It is pointed out that in a plasma behind a magnetically driven strong shock generated in a pulsed type accelerator, the internal energy will equal the kinetic energy only for a specific case. It is shown that the kinetic energy exceeds the thermal energy when the shock overtakes a uniformly moving fluid. In nonsteady flow in a constant area duct further conversion of thermal to kinetic energy is achieved when the strong shock is permitted to collide head-on with a complete rarefaction wave. (B.O.G.)

17462

EXPERIMENTAL TWO-BEAM EXCITATION OF ELECTRON OSCILLATIONS IN A PLASMA WITHOUT SHEATHS. M. J. Kofoid (Boeing Scientific Research Labs., Seattle). *Phys. Rev. Letters* 4, 556-7(1960) June 1.

Coherent standing waves of longitudinal electron oscilla-

tions were excited in a plasma by two independent oppositely directed electron beams at 65 ev, having no electrode sheaths. Strong sinusoidal standing waves, with two loops between electrodes, were found at 550 Mc/sec only when both beams and the plasma were present. Taking the distance between the electrodes as a wavelength, the phase velocity was  $1.10 \times 10^8$  cm/sec; the electron velocity of either beam was  $0.48 \times 10^8$  cm/sec. A single-loop standing wave was established with a beam energy of 74 ev. With either one or two loops, the standing wave amplitude fell gradually to zero when the voltage was increased or decreased  $\sim 3$  volts from the stated value. An oscillation frequency spectrum and the test apparatus arrangements are illustrated. (B.O.G.)

17463

PLASMA STABILITY AND BOUNDARY CONDITION. F. C. Hoh (Royal Inst. of Tech., Stockholm). Phys. Rev. Letters 4, 559-61 (1960) June 1.

The validity of the classical theory of charged particle diffusion across a magnetic field is discussed. Lehnert found agreement with classical theory for fields weaker than a certain critical value  $B_c$ , beyond which this theory was observed to be invalid. It is shown that this phenomenon can be explained by an instability of the wall sheath. It is postulated that the plasma becomes unstable when the boundary conditions are not satisfied because the ion velocity normal to the wall on entering the sheath can be reduced by a magnetic field. The discussions are valid for partially ionized gases; the corresponding situation for fully ionized plasma remains to be investigated. The present theory appears to connect the classical diffusion theory and the ion wave theory in a natural way. (B.O.G.)

17464

DYNAMIC PROPERTIES OF XENON HIGH PRESSURE ARCS. Hans-Jürgen Hentschel (Technische Hochschule, Karlsruhe, Ger.). Z. angew. Phys. 12, 223-30 (1960) May. (In German)

An alternating current component, whose frequency and amplitude were controllable, was superimposed on the xenon arc operating on direct current. The modulated fraction of the arc and radiation was measured at current modulation degrees to 45% in the frequency range from 100 Hz to 25 kHz. The phase loci were determined with special care. The radiation of the arc was detected both for the total arc and for individual arc constituents separated according to continuum and lines. The electrical behavior of the xenon arc can be described by an equivalent circuit in which a series connection is taken from a resistor and an inductor, which are frequency dependent, parallel to the resistance of the direct current pulse. The arc alternating voltage leads the current. The radiation amplitude at higher power concentration in the arc is less dependent on the frequency, at lower concentrations it decreases sharply at frequencies over several kHz. The radiation phase at increasing frequencies is distorted with respect to the current phase with values from  $10^{-3}$  to  $10^{-6}$  sec. The nonstationary heat conduction and the temperature distribution, but not the local temperature equilibrium between the plasma components, are responsible for this. Propagation patterns in the form of a heat wave could be detected only for low frequencies. (tr-auth)

17465

THE DECAY OF ELECTRIC ARCS. I. THEORETICAL CONSIDERATIONS. Gerhard Frind (Siemens-Schuckertwerke, Erlangen, Ger.). Z. angew. Phys. 12, 231-7 (1960) May. (In German)

The effect of the binding energy of molecules on the

form of the temperature distribution curve  $T(r)$  of an electric arc is described. In weakly bound molecules such as  $O_2$  or  $S_2$ , a narrow hot core is formed in currents of several amperes. In strongly bound molecules such as  $N_2$ , a core first appears at high current intensities. It can be shown that the decay of the heat conductivity function  $S$ , the temperature  $T$ , and the conductance  $G$  in a sudden currentless arc can be described generally only by a spectrum of time constants. These can be replaced by two time constants, a small one which describes the decay of the narrow arc core and a large one which describes the cooling of the broad temperature rise from which the core arises. (tr-auth)

17466

BUILD-UP OF ELECTROMAGNETIC WAVES IN A PLASMA MOVING IN A NONDISPERSIVE MEDIUM IN THE PRESENCE OF A CONSTANT MAGNETIC FIELD. G. G. Getmantsev and V. O. Rapoport. Zhur. Eksptl'. i Teoret. Fiz. 38, 1205-11 (1960) Apr. (In Russian)

A dispersion equation was obtained which describes the propagation of plane electromagnetic waves in a plasma beam moving in a fixed plasma along the lines of force of a constant and homogeneous magnetic field. The damping (or build-up) coefficients of the waves as a function of time were found for a rarefied plasma moving along the magnetic field through a nondispersive dielectric. (auth)

17467

RELATIVISTIC KINETIC EQUATION FOR A PLASMA. [PART] II. Yu. L. Klimontovich. Zhur. Eksptl'. i Teoret. Fiz. 38, 1212-21 (1960) Apr. (In Russian)

The equation chain for relativistic distribution functions previously obtained is used to deduce a second approximation relativistic kinetic equation for a plasma. A kinetic equation in which only retarded interaction of charged particles is taken into account is first derived. In a particular case this equation is identical to that derived by Belyaev and Budker. The Fokker-Planck relativistic equation for a plasma in which account is made of retarded interaction of the particles and excitation of plasma oscillations by nonequilibrium charged particles is also considered. (auth)

17468

CONTRIBUTION TO THE THEORY OF ELECTRON GAS CONDUCTIVITY IN A STRONG MAGNETIC FIELD. V. G. Skobov. Zhur. Eksptl'. i Teoret. Fiz. 38, 1304-10 (1960) Apr. (In Russian)

The conductivity of an electron gas in perpendicular electric and magnetic fields is investigated for  $\omega\tau \gg 1$  ( $\tau$  is the electron relaxation time,  $\omega$  is the cyclotron frequency). Elastic scattering of electrons on fixed short range force centers is considered. Interaction between the electrons and the scatterers is treated without aid of perturbation theory. In the final result the conductivity is expressed as a function of the magnetic field and the exact amplitude for scattering of a zero energy electron on a single center in the absence of a magnetic field. (auth)

17469

DIFFUSION DETERMINED AMPLIFICATION PROCESSES IN PLASMA. Hans Rother (Techn. Physikalisches Institut der Deutschen Akademie der Wissenschaften, Berlin). p.267-9 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In German)

A general theory of diffusion-waves is developed, first

giving straightforward computation of amplification criteria, propagation, and resonance from the fairly complex dispersion relations, also using a complete set of basic equations in contrast to previous workers. A short discussion is given of applications to the theory of moving striations in gas discharges and to development of waves in gases at high electric fields (influence on electric breakdown). (auth)

17470

ION FORMATION IN RARE GASES WITH HYDROGEN ADDITIONS. M. Pahl and U. Weimer (Max-Planck-Gesellschaft, Hechingen, Ger.). p.293-6 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In German)

Reactions between slow (thermal) ions and neutral molecules can have large cross sections and can, therefore, greatly influence the formation of charge carriers in a plasma. The formation of ions in the stationary column operated with the rare gases He, Ne, Ar, with additions of 0.5 to 8.0% H<sub>2</sub> is investigated by means of an effusion-mass-spectrometer. In Ar + H<sub>2</sub> the formation of ArH<sup>+</sup> predominates, while in Ne + H<sub>2</sub>; H<sup>+</sup> and NeH<sup>+</sup> occur with equal intensity, and in He + H<sub>2</sub>, H<sup>+</sup> predominates within certain ranges of pressure. Possible processes of ion formation in the positive column are discussed in connection with the measured ion effusion currents. (auth)

17471

HIGH FREQUENCY PLASMAS AT LOW PRESSURES. Albert J. Hatch (Argonne National Lab., Lemont, Ill.). p.314-19 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Typical results of a survey experimental investigation of high frequency-low pressure plasmas are presented. Plasmas are established between plane parallel metal electrodes with 15 cm separation at a frequency of 15 Mc/s through a pressure range of  $3 \times 10^{-6}$  to 0.5 mm Hg in air. Principal phenomena investigated are multipacting plasmas, electron diffusion plasmas and high frequency plasmoids. A new rf probe technique is described. External features observed include a plasma map showing various plasma zones as a function of pressure and applied rf voltage. Internal features include plasma d-c space potential, penetration of applied rf fundamental voltage, and amplitude and phase of organized oscillatory electron motion, all as functions of inter-electrode position. (auth)

17472

PINCHING, PASSING AND CHOPPING OF CURRENT IN A NECK OF A DISCHARGE GAP. G. G. Timofeyeva (All-Union Electrotechnical Inst., Moscow). p.343-5 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

In a cylindrical tube with a narrow neck three ranges of currents for low-pressure arc exist: low current range when no chopping occurs, medium current range when current chopping is probable, and high current range when again no current chopping is possible. Absence of current chopping of heavy current arcs is due to magnetic pinching of the arc column to a diameter less than that of the neck. In this case no considerable rarefaction of the gas in the

neck occurs. This conclusion was confirmed by instantaneous photographs of the arc column obtained with an image convertor tube. Chopping of the arc current is prevented when the arc column is contracted by the self magnetic field to a diameter which is smaller than the diameter of the neck. (auth)

17473

EMISSION AND ABSORPTION IN SPARK PLASMAS.

L. Herman (Observatoire de Paris, Meudon, France). p.403-7 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

An attempt is made to determine the gas temperature of a decaying plasma by comparison of experimental and theoretical values of the three body recombination coefficients. (auth)

17474

MASS SPECTROMETRIC STUDY OF ION EMISSION AND ION DISTRIBUTION OF GAS DISCHARGE PLASMA.

O. Reifenschweiler (N. V. Philips' Gloeilampenfabrieken, Eindhoven, Netherlands). p.541-8 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume I." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In Dutch)

A method is discussed for investigating the ion emission from gas discharge plasmas, enabling conclusions to be drawn on the ion-density distribution inside the plasma. Both radio-frequency and arc discharges in hydrogen are used. An ion-extraction system and an electrostatic-lens system produce an image of the plasma boundary and the current-density distribution of the various ion types is measured along the diameter of this image. The relative contributions of the ion types are found to differ strongly. A relatively weak magnetic field perpendicular to the discharge axis causes the emission maxima of the plasma boundary to shift, the extent of the shift varying with the type of ion. Finally, a movable extraction probe is described, suitable for the determination of ion densities at arbitrary points inside the plasma. (auth)

17475

LINEARIZED PLASMA DYNAMICS, AN INTRODUCTION TO THE STUDY OF SMALL OSCILLATIONS AND THE GROWTH OF INSTABILITIES IN A PLASMA. W. B.

Thompson (Atomic Energy Research Establishment, Harwell, Berks, Eng.). p.555-65 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Some of the physical models and mathematical techniques that have been used to represent the motion of a plasma, when departures from equilibrium are small, are described. The transmission of small signals through a plasma, the theory of electromagnetic wave propagation, transmission of sound, and the stability of configurations of magnetohydrostatic equilibria are included. (M.C.G.)

17476

TRANSPORT PHENOMENA IN A FULLY IONIZED GAS INCLUDING WAVE-PARTICLE INTERACTIONS. K. S. W. Champion and S. P. Zimmerman (Tufts Univ., Medford, Mass. and Air Force Cambridge Research Center, Bedford, Mass.). p.589-94 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Upp-

sala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The statistical mechanical theory of a nonequilibrium, fully ionized gas is developed, both in classical and quantum form using the Lorentz Gauge. The interaction of the electrons and ions with electromagnetic waves is thus included in the theory. In addition, the effects of coherent particle motions, such as plasma oscillations, are included. The action of external applied electric and magnetic fields is also added. Thus, in the most general case, the theory includes the interactions of the particles with each other, with nonperiodic fields, and with transverse and longitudinal vector waves and with scalar waves. The appropriate Hamiltonian of such a system is developed. By using the canonical equations of motion, a generalized form of Boltzmann's equation is obtained, which is applicable to the system of particles and waves being considered. The corresponding wave mechanical form of this equation is derived. The statistical mechanical forms of the transport equations of this system are next considered, and it is shown that the presence of various kinds of wave motion modify the transport properties of a fully ionized gas. The magnetohydrodynamic equation is obtained by equating the time rate of change of momentum density to the divergence of the particle stress tensor and the vector sum of the various force terms. Starting from the principle of conservation of energy, the equation of energy transport is developed by an analogous method to that used for the hydromagnetic equation. (auth)

**17477**

SEMI-QUANTUM TREATMENT OF INTERACTIONS IN A PLASMA. Marc Feix (Laboratoire Central de l'Armement, Arcueil, Seine, France). p.595-8 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In French)

An interesting length in quantum plasma theory is the mean de Broglie wavelength of particles  $\lambda = \hbar/(mc) \propto \hbar/(mKT)^{1/2}$ . A plasma shows both individual and collective behavior, and the individual behavior is correctly described by a simple cut-off of the Coulomb interaction for distances shorter than  $\lambda$  (so quantum effects are important for temperatures above  $3 \times 10^6$ °C). For studying the collective aspect, an artificial potential  $(e^2/r)(1 - \exp(-\gamma r))$  is introduced with  $\gamma \propto \lambda^{-1}$  instead of the Coulomb potential, and Yvon's method is applied for the calculation of correlations between particle positions. This point of view is connected with that of Bohm and Pines (build-up with Fourier components of the particle density), and important quantum effects are found at temperatures  $KT$  below the "plasmon energy"  $\hbar \omega_p$ . Comparison between Debye length, interparticle distance, and  $\lambda$ , shows a classification of plasma zones in a density vs. temperature diagram. (auth)

**17478**

THE PLASMA-SHEATH TRANSITION IN THE PRESENCE OF A MAGNETIC FIELD. J. E. Allen and F. Magistrelli (Comitato Nazionale per le Ricerche Nucleari, Rome and Università, Rome). p.599-603 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Experiments are reported on the plasma-sheath transition in the presence of a magnetic field. The measurements were made using a low pressure mercury discharge tube in

which an azimuthal or "pinch-type" magnetic field could be applied. (auth)

**17479**

EXPERIMENTS ON DIFFUSION IN A PLASMA COLUMN IN A LONGITUDINAL MAGNETIC FIELD. F. C. Hoh and B. Lehnert (Royal Inst. of Tech., Stockholm). p.604-8 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

An extension is made of earlier investigations on the diffusion processes in a long discharge tube placed in a longitudinal magnetic field. Pressures in the range from 0.17 to 4 mm Hg, discharge currents between 50 and 400 ma, and magnetic field strengths up to  $0.8 \text{ Vs/m}^2$  have been used. A study of the potential drop along the positive column gives information about the balance between the production of charged particles and the loss of the particles by diffusion to the tube wall. For helium the results can be shown to agree with the binary collision theory in a range of magnetic field strengths below a certain limit. Above this limit an instability sets in which indicates a rapid increase in the rate of escape of particles across the magnetic field. The phenomenon has been observed in a number of different gases. The onset of the instability depends upon the nature of the gas, its density and on the radius of the tube. On the other hand, no dependence on the length of the discharge tube or on that of the magnetic field has been observed, provided that these lengths exceed some fifty tube diameters. The influences of external impediments in the discharge circuit and of imperfections in the magnetic field have been found to be negligible. (auth)

**17480**

ON HYDROMAGNETIC STABILITY OF THE TOROIDAL LOW PRESSURE PLASMA. B. B. Kadomtsev (Atomic Energy Inst., Academy of Sciences, Moscow). p.609-10 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The problem of plasma stability in strongly curved and strongly inhomogeneous magnetic fields is discussed. In the case of closed magnetic field lines, only the interchange perturbations can lead to instability. The interchange instability may also occur in systems with unclosed lines if the pressure gradient is great enough. This result is generalized for the case of any toroidal system. (M.C.G.)

**17481**

STABILITY OF HELICALLY INVARIANT FIELDS.

Russell M. Kulsrud (Princeton Univ., N. J.). p.611-13 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

This paper was previously abstracted from the original language and appears in NSA, Vol. 14, as abstract No. 4055.

**17482**

ON THE STABILITY OF A LINEAR PINCH WITH VOLUME-CURRENTS. Karl Ulrich von Hagenow (Max-Planck-Institut für Physik und Astrophysik, Munich). p.614-19 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The stability of a cylindrical, ideal plasma is investigated, and the results are compared with numerical com-

putations of the instabilities for a particular configuration. An  $m = 1$  instability is shown to exist for all sufficiently long cylinders with net axial current which are surrounded by a vacuum field of sufficient extension. The dependence of the growth-rates on the wave-number  $k$  for different  $m$  values in the numerical example can be understood with the help of a stability criterion given by Suydam and another one derived in this paper. (auth)

17483

STABILITY OF ELECTROMAGNETIC PLASMA CONFINEMENT IN SPHERICAL GEOMETRY. James W. Butler (Argonne National Lab., Ill.). p.620-5 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

A conducting fluid sphere at the center of a spherical resonant cavity may be held in pressure equilibrium by exciting certain cavity modes and also applying a proper steady magnetic field. The stability of this configuration is investigated by an energy method. It is found that the stability picture is most favorable for core sizes less than about  $\frac{1}{10}$  of the outer shell diameter, even though unstable behavior still persists for long perturbation wavelengths. Also discussed are modifications which might possibly result in a stable configuration. (auth)

17484

VELOCITY DISTRIBUTION OF ELECTRONS IN A STRONG ELECTRIC FIELD. L. M. Kovrizhnykh (Lebedev Inst. of Physics, Moscow). p.627-33 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

A method of finding nonstationary solution of the Boltzmann equation for the case of strong electric fields was developed. A formula for the electron distribution function in a completely ionized plasma placed in a strong electric field was found. It is shown that in the first approximation this is a Maxwell distribution superposed on a mean drift of the electron gas. The drift velocity in the first approximation grows proportionally to time, while the temperature remains constant. (auth)

17485

THE VELOCITY DISTRIBUTION OF PLASMA ELECTRONS IN AN EXTERNAL ELECTRIC FIELD. Ira B. Bernstein and Irving N. Rabinowitz (Princeton Univ., N. J.). p.634-6 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The Fokker-Planck equation for a plasma composed of electrons which collide only with an equal charge of infinitely massive ions was solved on an IBM-704 computer. The results to date indicate that on the basis of this model, for sufficiently strong electric fields, there occurs the phenomenon of electron runaway and also indicate that there develops a distribution in velocity along the accelerating electric field exhibiting two maxima. This latter situation is presumably unstable. (auth)

17486

SUPRA-THERMAL PARTICLES. K. J. Le Couteur (Australian National Univ., Canberra). p.637-9 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume

II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The production of suprathermal particles in agitated plasmas is discussed by using the Fokker-Planck equation for the ion-velocity distribution function. The conditions for stationary solutions are considered in detail. (auth)

17487

ACTION OF AN ALTERNATING ELECTRIC FIELD ON A COMPLETELY IONIZED PLASMA. H. Baglin, A. Brin, J. L. Delcroix, Y. Ozias, and J. Salmon (Commissariat à l'Énergie Atomique, Paris). p.640-7 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In French)

The equation giving the distribution function of the electrons in a steady-state, for a fully ionized plasma in an a-c field, are provided from the Fokker-Planck equation. The electric conductivity is complex and depends on the frequency. (auth)

17488

THE EFFECT OF RUNAWAY ELECTRONS ON THE HEATING OF PLASMA. J. A. Wesson (Associated Electrical Industries, Ltd., Aldermaston, Berks, Eng.). p.648-52 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

When an electric field is applied to a plasma, some electrons undergo continuous acceleration. If the purpose of the electric field is to heat the plasma, this acceleration constitutes an energy loss. The importance of this effect is considered for the cases of constant electric field and constant current density. The heating of the plasma by runaway electrons is shown to be small. (auth)

17489

THE INTERACTION OF A BEAM OF CHARGED PARTICLES WITH A PLASMA. R. A. Demirkhanov, A. K. Gevorkov, and A. F. Popov (Academy of Sciences, Moscow). p.665-70 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Investigation of the high-frequency oscillations generated in plasma by a fast electron beam was carried out. The excited oscillations were detected by a coaxial probe. When a fast electron beam is injected into the plasma region with velocity much greater than the mean thermal velocity of the plasma electrons, electrostatic waves are generated, and a transfer of beam energy into oscillation energy takes place. The shift of intensity maximum over the frequency range and its dependence on the plasma density at constant values of current and beam velocity were studied. (M.C.G.)

17490

EXPERIMENTAL AND THEORETICAL INVESTIGATION OF THE INTERACTION OF AN ELECTRON BEAM WITH PLASMA. I. F. Kharchenko, Ya. B. Fainberg, P. M. Nikolayev, E. A. Kornilov, E. A. Lutsenko, and N. S. Pedenko (Ukrainian Physico-Technical Inst., Academy of Sciences, Kharkov). p.671-80 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Results of experimental investigations of the interaction

of modulated and unmodulated high energy electron beams with plasma are presented. It is shown that oscillations with a frequency near that of the plasma natural oscillation frequency arise in a beam moving through plasma. The dependence of the amplitude of oscillation upon frequency and plasma parameters was determined. Coherent energy loss effects of the electrons in modulated and unmodulated beams passing through plasma were investigated. (auth)

17491

ON THE INTERACTION BETWEEN SPACE CHARGE WAVES AND ELECTROMAGNETIC WAVES IN A GOLD PLASMA. O. E. H. Rydbeck (Chalmers Tekniska Högskola, Göteborg). p.681-6 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The interaction between space charge waves and electromagnetic waves in a cold plasma, excited by an electron stream, was studied in the case of a strong focusing field in the drift direction. It is shown that electromagnetic waves may leave the plasma under certain restricted conditions. A first order approximation to the actual energy transfer is derived and possible applications are discussed. (auth)

17492

ON THE POSSIBILITIES OF OSCILLATORY INSTABILITIES IN TIME OF A RING CURRENT. H. Wilhelmsson (Chalmers Tekniska Högskola, Göteborg). p.687-9 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

A cold electronic plasma is considered which has the shape of a torus, the electrons of which are assumed to have an average drift motion along the torus. A static magnetic field in the direction of the drift motion is assumed. The possibilities of complex frequency—roots of the dispersion relation, in which the wave propagation constant is fixed by cyclic boundary conditions, are analyzed. It was found that if the ring current runs through an ionized medium or if it interacts with slow wave structures oscillatory instabilities may occur. (auth)

17493

HIGH-FREQUENCY WAVES IN IONIZED GASES. Sanborn C. Brown (Massachusetts Inst. of Tech., Cambridge). p.691-6 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Interactions of plasma with electromagnetic waves, in the presence of a magnetic field, are divided into four regions. Each region shows certain characteristics as to type of interaction. The "ordinary" waves are not affected by the magnetic field, where electric ( $\vec{E}$ ) and magnetic ( $\vec{B}$ ) vectors are parallel and propagation is at right angles to the magnetic field. If the propagation is along  $\vec{B}$  and  $\vec{E}$  is perpendicular, then a "right-handed" or "left-handed" wave can be defined. The fourth type of wave, called "extraordinary," is transverse to the magnetic field but not to the direction of propagation. In the absence of a magnetic field the properties of radiation from a plasma are a function of electron density. (M.C.G.)

17494

ON ELECTROMAGNETIC PROPERTIES OF RELATIVIS-

TIC PLASMA. V. P. Silin (Lebedev Inst. of Physics, Moscow). p.697-703 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The dielectric permittivity of a relativistic electron-ion plasma is considered taking into account spatial dispersion. Formulas for screening radius and skin-layer depth were obtained. Undamped and weakly damped oscillations of the plasma are considered. (auth)

17495

ON THE PROBLEM OF NONLINEAR PLASMA OSCILLATIONS. Hans Rother (Physikalisch-Technisches Institut der Deutschen Akademie der Wissenschaften, Berlin). p.704-6 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In German)

The behavior of "electrostatic" plasma waves, which grow in a nearly collision-free plasma, essentially depends on the initial conditions of the system. The shape of the resulting wave is not an arbitrary one, as was concluded by previous workers. Two possibilities are important: Very few particles have initial velocities near the wave velocity, or on the other hand, many particles are initially available in that range. Systems in which the electrons fit a quasi thermodynamical equilibrium admit waves only, which in the limiting case of small amplitudes obey the well-known dispersion relation, the wave-length being large compared with the Debye radius. The effect of trapped particles is negligible in this case. Systems of the second type admit stationary waves, if the distribution function takes the form  $f = f(m/2 v^2 - e\varphi)$ . The deviations from this "standard" distribution determine the growing up of waves. Numerical calculations of simple models are still under investigation. (auth)

17496

LOW FREQUENCY WAVES IN MAGNETO IONIC MEDIA. Olaf E. H. Rydbeck and Alf R. Thomasson (Chalmers Tekniska Högskola, Göteborg). p.707-13 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

It is well known that electromagnetic disturbances can propagate in ionized media at frequencies much lower than the plasma and gyro-frequencies. Such low-frequency radiation, which may be excited by corpuscles or outside waves, shows peculiar characteristics, which are discussed. Such waves may even be trapped in the ionized medium provided certain conditions are fulfilled. (auth)

17497

OSCILLATORY PROPERTIES OF GYROMAGNETIC ELECTRIC COLD PLASMAS WITH DRIFT MOTION. Hans Wilhelmsson (Chalmers Tekniska Högskola, Göteborg). p.714-17 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The problem under investigation is the propagation of waves in a cold plasma with drift motion in the presence of a static magnetic field of arbitrary strength in the direction of drift motion. Cylindrically bounded and infinitely extended media are considered. The case where the drifting

medium interpenetrates a medium without drift-motion is considered, using small signal theory and assuming the d-c current density and d-c electron density are constant in space. The effects of collisions are considered. The derived solutions are relativistic and exact under the assumptions made. In the cylindrical case, the dispersion relation is derived in a simple form for a drifting medium and metallic boundaries. In the case of an infinitely extended medium, the problem of propagation in a direction that makes an arbitrary angle with the magnetic field is studied. The dielectric tensor and the dispersion relation for oblique propagation are found. (auth)

17498

ON THE INDEX OF REFRACTION OF SPATIALLY PERIODIC PLASMA. C. H. Papas (California Inst. of Tech., Pasadena, Calif.). p.718-20 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

A knowledge of the change produced in the index of refraction of a uniform plasma by the spontaneous generation of coagula or inhomogeneities is essential to the use of electromagnetic waves as a diagnostic tool. The general problem is a difficult one to handle, but certain non-trivial cases are mathematically tractable. One of these, which is also of some practical import, occurs when the inhomogeneities are periodically distributed throughout the plasma. Here this special case is analyzed within the framework of the theory of periodic structures. The problem is reduced by virtue of Floquet's theorem to an equivalent problem for the domain of a unit cell with periodic boundary conditions. An approximate solution is obtained by a simplified theory. As a specific application the calculation for a plasma with periodically spaced spherical inhomogeneities is worked out in detail. (auth)

17499

PLASMA RESONANCE COUPLING IN IONIZED MEDIA. O. E. H. Rydbeck (Chalmers Tekniska Högskola, Göteborg). p.726-8 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

It is shown that ordinary reflection of electromagnetic waves in inhomogeneous ionized media may be considered as a plasma resonance coupling. A similar coupling explains the magneto-ionic triplet splitting and the resonance radiation from excited plasma. (auth)

17500

A METHOD FOR STUDYING THE SPACE DISTRIBUTION OF ELECTRONS IN A PLASMA. A. I. Anisimov, V. E. Golant, B. P. Konstantinov, and N. I. Vinogradov (Physico-Technical Inst., Academy of Sciences, Leningrad). p.729-36 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

A method for studying the electron spatial distribution is described, applicable to a plasma with a high electron density. The method is based on measurements of the phase of electromagnetic waves of various frequencies reflected by the plasma. The results of the experimental development of this method and the data obtained for a decaying hydrogen plasma are presented. (auth)

17501

MICROWAVE RADIATION MEASUREMENTS OF VERY

HOT PLASMAS. Charles B. Wharton (Univ. of California, Livermore). p.737-42 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

A study of the microwave radiation from various controlled fusion experiments is presented. A brief mention of some modern radiation theories is made and experimental verification for certain aspects of these theories is demonstrated. Of particular interest is the relationship between the intensity of radiation and the plasma electron temperature. Correlative measurements are reported whose results at least qualitatively substantiate the results obtained by microwave radiometry. (auth)

17502

RADIATION PATTERNS OF THE NOISE EMISSION FROM A GASEOUS DISCHARGE. N. George (California Inst. of Tech., Pasadena and Hughes Aircraft Co., Culver City, Calif.). p.743-54 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Theoretical and experimental radiation patterns are given in spectral form for the thermal radiation from a cylindrical discharge column which is adjacent to a long thin slot in a metallic plane. A spatial distribution is predicted which exhibits interference minima and maxima when the length of the slot and the wavelength of the emission are the same order of magnitude. The analysis is based on Maxwell's equations and the Leontovich-Rytov distributed-source generalization of Nyquist's noise formula. Fraunhofer pattern measurements are presented in which an argon source is used to excite slots of  $7.3\pi$  and  $9.5\pi$  radians in length. Data are also presented to show the effects of variations in the pressure and the d-c current of the discharge. The pattern measuring apparatus is a Dicke radiometer having the following characteristics: frequency 9200 Mc/s, bandwidth to the detector 16 Mc/s, modulation frequency 1000 c/s, and residual noise level 0.3 rms°K. An interference phenomenon is predicted by the theory and demonstrated by an experiment, even though the source excitation is spatially distributed and essentially uncorrelated in time and in space. The patterns are not even approximately Lambertian, e.g., a thin slot of  $9.5\pi$  radians exhibits a pattern having nine relative maxima in  $180^\circ$  with the maximum emission at  $63^\circ$  from the normal. (auth)

17503

CALCULATION OF THE ELECTRONIC DENSITY AND COLLISION FREQUENCY IN A DECAYING PLASMA. T. L. Dutt and A. G. Stainsby (General Electric Co., Ltd., Wembley, Eng.). p.755-61 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Experimental results on the transmission of signals having frequencies ranging from 100 Mc/s to 10,000 Mc/s between probes external to a glass tube containing a decaying plasma yielded multiple resonances. When the frequencies at which these resonances occurred were plotted versus time, it was observed that they lay on one of four lines. An attempt was made to explain these resonances in terms of the complex conductivity and complex dielectric constant of the plasma. These quantities were derived from the simple equation of motion of the electron in a plasma, terms de-

scribing collision damping and space charge being included. Maximum transmission can in fact be shown to occur for four distinct cases, two of which are derived treating the plasma as a conducting medium where the complex conductivity is applicable, and two obtained using the complex dielectric constant to describe the medium in relation to the transmission via the induction field associated with the probes. The formulas involve collision frequency and electronic density, and values for these quantities and their variation with time are derived from the lines. (auth)

17504

FORMULAS FOR ESTIMATING WIDTHS OF SPECTRAL LINES EMITTED FROM PLASMAS AND THEIR LIMITS OF VALIDITY. Henry Margenau (Yale Univ., New Haven). p.799-807 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

General directives are given for estimating the width of spectral lines broadened by Stark effects. The approach involves defining physical conditions under which impact and statistical regions are valid, and in each case the regime of the Doppler effect is held in view. Three different regions in the  $n$ - $T$  plane are distinguished and plotted,  $n$  being the number density of ions (electrons) and  $T$  the absolute temperature. In region I both electrons and ions can be treated by impact theory. In II, ions are subject to statistical and electrons to impact description, whereas in III both behave statistically. (auth)

17505

ADVANCES IN THE THEORY OF STARK BROADENING OF SPECTRAL LINES. H. R. Griem and A. C. Kolb (Univ. of Maryland, College Park and U. S. Naval Research Lab., Washington, D. C.). p.808-12 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Previous theories of spectral line broadening in a plasma by fields due to electrons and ions led to discrepancies of  $\approx 2$  with experimentally determined profiles. For lines subject to a linear Stark effect, an adequate treatment of the broadening caused by collision-induced transitions between Stark levels by electron impacts and of the correlation and shielding effects on the ion field-strength distribution function was lacking. For lines affected by the quadratic Stark effect the general practice in computing line profiles was to employ Stark coefficients appropriate for a static field. It is shown that this adiabatic treatment is practically never valid for the perturbations caused by fast electrons which give the major contribution in this case, whereas ions and electrons are of equal importance in case of linear Stark effect. These various difficulties were resolved by an impact theory generalized for overlapping lines, by a more exact integration of the time-dependent Schrödinger equation and by calculations of the field-strength distribution function without neglecting interactions between perturbers. For the  $H-\beta$  line of hydrogen, a 10% agreement with the new theory was obtained over an intensity range of two decades and for neutral helium lines agreement was reached within the experimental accuracy even in case of He 3965 with its forbidden component. Whereas the use of quadratic Stark coefficients yielded a ratio of width to shift of 1.18, the theory presented gives values between 1 and 4 for this quantity, which is again in agreement with experiment. The calculated line

profiles depend only slightly on temperature and can be used to deduce electron densities in dense plasmas from measured line profiles with much improved accuracy. (auth)

17506

TEMPERATURE MEASUREMENT IN PLASMA LAYERS BY ABSORPTION. A. Bauer (OSRAM-Studiengesellschaft, Augsburg, Ger.). p.817-23 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In German)

The radiation of a thermal optically thick gas plasma is equal to that of a black-body of the same temperature. The method of temperature-measuring which insists on the evaluation of absolute intensity and optical thickness  $\tau$  is investigated, especially for end-on observed arcs. The well-known intermittent photometry method for measuring  $\tau$  is compared with a bichromatic method. Good results for obtaining the temperature can be realized with the first method for  $\tau > 1$  and for the second method for  $\tau > 2$ . Self reversal becomes disturbing at  $\tau = 5$  for end-on observed arcs of normal proportion and even more so the greater  $\tau$  becomes. The investigated method of temperature-measuring does not need "optically thick layers" in every case but it is most exact in a narrow range of optical thickness, (in this case  $3 < \tau < 5$ ) which is often obtained in the middle of spectral lines. The temperature of a Xenon discharge obtained with the more simple bichromatic method from some infrared lines had the average amount of 8740°K, with a calculated maximum error of 2%. A less accurate temperature evaluation from the intensity of the infrared continuous radiation yielded 8750°K and from the electrical conductivity 8400°K. (auth)

17507

THE MEASUREMENT OF ELECTRON TEMPERATURE IN HIGH TEMPERATURE PLASMAS. S. Kaufman and R. V. Williams (Associated Electrical Industries, Ltd., Aldermaston, Berks, Eng.). p.824-8 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The method is based on the simplifying features of helium-like ions and on the rapid establishment of equilibrium between the processes of populating and de-populating the  $2^3P_0$ -level. The specific intensity of the emission line  $2^3S_1 - 2^3P_0$  can then be deduced as a function of the electron temperature (Kaufman and Williams, 1958). In order to test the basic assumption that the electron velocity-distribution is Maxwellian for the very fast electrons which produce the atomic excitation, more than one member of the iso-electronic sequence must be studied. Also, an expression containing the relative emission from two members of the sequence eliminates the electron concentration which can only be estimated at present. The intensities of C V and B IV lines from Sceptre IIIA were measured with a combination of a monochromator and a photomultiplier. For typical torus conditions, the maximum electron temperature attained was in the range  $(2-3) \times 10^{16}$  K. The electron temperature was unaltered by the introduction of the methane. The results suggest that any existing departure from a Maxwellian distribution of electron velocities did not seriously affect the value of electron temperature derived by this method. (auth)

17508

THE SPECTROSCOPIC STUDY OF ELECTRON ENERGY

IN A LINEAR PINCHED DISCHARGE. A. H. Gabriel (Atomic Weapons Research Establishment, Aldermaston, Berks, Eng.). p.829-32 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Using a 2500 joule low inductance condenser bank, two types of discharge are investigated; one in pure deuterium, and the other in deuterium containing 5% of oxygen, which is believed to have only a small effect on the nature of the discharge. These are studied by streak and Kerr cell methods and time-resolved spectroscopy. The variation of the spectra in space and time is investigated, and absolute measurements made on line and continuum intensities during the first pinch. The possibility of fitting these measurements into different patterns of excitation and ionization equilibrium is considered. (auth)

17509

THE INTERPRETATION IN TERMS OF ATOMIC COLLISION PROCESSES OF A MEASUREMENT OF THE ABSOLUTE INTENSITIES OF SOME OF THE BALMER SPECTRAL LINES AS EMITTED BY A DEUTERIUM DISCHARGE IN ZETA. R. W. P. McWhirter, W. G. Griffin, and T. J. L. Jones (Atomic Energy Research Establishment, Harwell, Berks, Eng.). p.833-8 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The observed absolute intensities of the first six members of the Balmer series as emitted by a deuterium discharge in Zeta are interpreted in terms of a model for excitation which includes step-wise excitation and the effect of the imprisonment of resonance radiation. (auth)

17510

CALCULATIONS OF THE PINCH IN THE HYDROMAGNETIC APPROXIMATION. K. Hain and G. Hain (Max-Planck-Institut für Physik und Astrophysik, Munich). p.843-8 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

To a fully ionized plasma in an infinite cylinder a longitudinal electrical field is applied. The induced longitudinal current flow interacts with its own magnetic field and causes the gas to move inward ("pinch" effect). The plasma is so dense, that the hydromagnetic approximation is valid. The resulting partial differential equations for the gas together with Maxwell's equations are solved numerically. Finite conductivity and ohmic heating depending on temperature and heat conductivity depending on both temperature and magnetic field are taken into account. It is shown that the thermal conductivity is of great importance in the early stages of the pinch. A reversed  $B_z$ -field can be achieved by assuming an electrical conductivity of the wall in the direction of some angle  $\alpha$ . (auth)

17511

THE TRAPPING OF GAS IN A FAST-PINCH DISCHARGE. N. J. Phillips (Atomic Weapons Research Establishment, Aldermaston, Berks, Eng.). p.849-52 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

A simplified model of a process by which gas is trapped inside a collapsing fast-pinch discharge is considered. It is assumed that the discharge is in the form of a cylindrical sheet of ionized gas surrounding a gas of cold un-ionized atoms. To simplify the problem it is assumed that collisions between the neutral atoms and the charged particles in the current sheet result mainly in the ionization of the neutrals and that the relative amount of elastic scattering is small. A simple parameter is obtained which determines the efficiency of the trapping process described. It is shown that the efficiency of trapping increases with the initial gas density in the discharge tube. (auth)

17512

CINEMATOGRAPHIC AND SPECTRAL INVESTIGATIONS OF PINCHED DISCHARGE IN GASES. Hartmut Zwicker (Technische Hochschule, Hanover). p.857-60 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In German)

The behavior of a pinched cylindrical 32 kJ discharge in helium, argon, and xenon with increasing gas-density is investigated by cinematographic and spectral methods within the range of pressure between  $2 \times 10^{-2}$  and 20 mm Hg. With increasing gas density new bright zones within the contracting plasma cylinder appear, the number of which changes during the contraction. The contraction velocity varies between 130 km/sec and 6 km/sec. The time resolved spectra of the middle-random-variation show, that the contracting current sheet is highly ionized already near the wall of the tube. The observed bright zones are explained as additional current sheets within the plasma cylinder. The possibility of their creation by a mechanism, similar to the skin-effect, is discussed. (auth)

17513

A COMPARATIVE STUDY OF THE FAST LINEAR Z-PINCH WITH HIGH AND LOW INDUCTANCE CONDENSER BANKS. H. A. B. Bodin, N. J. Peacock, and J. A. Reynolds (Atomic Weapons Research Establishment, Aldermaston, Berks, Eng.). p.861-6 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

An experimental investigation of the fast linear z-pinch is described for high and low initial rates of rise of current. A qualitative study using high-speed photographs reveals several features which are more favorable in the former case. An analysis of the radius and current variation with time obtained from both the electrical and photographic measurements is discussed and compared with theory. At high rates of current rise it is concluded that the heating and containment of the central plasma column becomes limited at or soon after the first maximum compression by currents which build up outside the central region. Values are given for the work done on the gas, the ion temperature (assuming no losses) and the energy in the magnetic field at the first maximum compression under different conditions. At high values of initial rate of current rise a marked improvement in stability is observed without a big reduction in compression heating for discharges with  $H_2$ . (auth)

17514

MEASUREMENTS OF CONDUCTIVITY ON LINEAR PINCH DISCHARGES BY MEANS OF MAGNETIC PROBES. H. Förster and J. Schlüter (Technische Hochschule,

Aachen). p.867-70 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

On linear pinch discharges the temporal and spatial distributions of the magnetic field were measured by magnetic probes. From these measurements the ratio of the conductivities parallel and perpendicular to the magnetic field were calculated and found to be in rough agreement with the theoretical value calculated by Spitzer. (auth)

**17515**

SOME MAGNETOHYDRODYNAMIC EFFECTS BY THE IMPULSE PLASMA CONFINEMENT. I. Ph. Kvartzhava, K. N. Kervalidze, and Ya. S. Gvaladze (Academy of Sciences, Moscow). p.876-83 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Photographs of plasma generated by pulsed electrical discharges were taken by a continuously recording streak camera. Plasma instabilities consisting of the ejection of plasma formations from the pinch surface were observed. These were caused by radial shock waves reflected from the axis of the pinch, which interacted with the magnetic field. Linear pinches (between electrodes) and induction pinches (electrodeless discharges) showed these effects. Magnetic probe measurements are discussed. (auth)

**17516**

OPTICAL AND ELECTRICAL STUDIES OF A LINEAR PINCHED DISCHARGE. R. Latham, F. L. Curzon, and J. A. Nation (Imperial Coll. of Science and Tech., London). p.884-7 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The results of photographic studies of the linear pinch are related to the measurement of the diameter of the discharge in the neighborhood of the first pinch and the correlation of the measured time to pinch with the snow-plough theory; the growth of instabilities; streak photography of the discharge through a slot in the anode; and linear pinches in tubes with metal liners. (auth)

**17517**

EXPERIMENTS WITH LINEAR PINCH AND INVERSE PINCH SYSTEMS. K. L. Aitken, J. N. Burcham, and P. Reynolds (Atomic Energy Research Establishment, Harwell, Berks, Eng.). p.896-900 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Thin current sheaths were produced with pinch and inverse pinch discharges in straight quartz tubes of length 70 cm and inside diameter 30 cm. The formation and subsequent stability of the sheaths was studied by means of magnetic probes. A comparison of the two systems under similar operating conditions shows the inverse pinch to be the more stable. Some evidence indicated that instabilities first appeared near the electrodes in the case of the inverse pinch. (auth)

**17518**

THE HEAT LOSSES TO ELECTRODES. Malcolm G. Haines (Imperial Coll. of Science and Tech., London).

p.901-3 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

A linear pinched discharge is considered in its steady state where there is a pressure and an energy balance. Under these conditions the joule heating caused by the axial current is balanced by bremsstrahlung radiation losses and by axial heat conduction to the electrodes. Relations between the maximum temperature at the center of the discharge, the axial current, the voltage across the electrodes, the mean line density and the radius of the discharge, and the separation of the electrodes, are developed showing a linear dependence of temperature on applied voltage, and that temperatures of  $10^6$  to  $10^7$  K are quite feasible with heat losses to electrodes being present. To obtain this analytical solution, the electrical and thermal conduction coefficients are assumed to have a  $\frac{1}{2}$  and  $\frac{5}{2}$  power dependence on temperature throughout the plasma. (auth)

**17519**

OHMIC HEATING OF FULLY IONIZED PLASMA OF HIGH DENSITY. K. H. Höcker and W. Kluge (Technische Hochschule, Stuttgart). p.904-11 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In German)

With the aid of a moment-approximation for the solution of the Boltzmann equation, the equations together with the collision integrals for ohmic heating are presented. Calculations of the temperature rise for ions and electrons, which were performed for selected cases of hydrogen plasmas are discussed. For the establishment of theoretical current-voltage characteristics of the linear discharge, a quasi-stationary consideration is made. The loss mechanisms treated are those due to free-free and free-bound radiation in nitrogen. The equations established thus can be used for temperature estimates (a) via the electrical conductivity and (b) via the magnetic pressure. For the case of (a), the electrical conductivity for nitrogen is presented. Experiments were conducted using a linear whirl-stabilized high current discharge in nitrogen. The length of the discharge column is up to 50 mm, its diameter approximately 2 to 3 mm. A small condenser bank (10 kV, 15  $\mu$ F; or 25 kV, 5  $\mu$ F) is then discharged over this stationary plasma column (temperature approximately 30,000°K). There occurs a short-time rise of the current to  $10^5$  amp. The behavior of the plasma column during this pulse discharge is ascertained by means of image converter photographs with effective exposure times of approximately  $10^{-7}$  sec. From the experimental data, including tentative determination of the discharge diameter from image converter photographs, rough estimates lead to temperatures in the range of  $6 \times 10^6$  to  $10^6$  K. (auth)

**17520**

ENERGY LOSSES FROM PLASMA BY RADIATION. V. D. Kirillov (Atomic Energy Inst., Academy of Sciences, Moscow). p.912-19 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Experiments aimed at finding out the mechanism of energy loss from a stable pinch having no contact with the discharge tube walls are described. These were performed

using a cylindrical porcelain discharge tube with electrodes. The tube was operated at discharge currents of several tens of kiloamperes, pressures of  $2 \times 10^{-1}$  to  $10^{-2}$  mm Hg of deuterium in longitudinal magnetic fields up to 24 kilo gauss. It was found that the flux of charged particles striking the tube walls is small. Experiments performed using an ionization chamber, vacuum spectrograph, and thermo-luminescent phosphor indicate that a considerable amount of the plasma energy is lost by vacuum ultraviolet radiation from impurities. (auth)

## 17521

LOS ALAMOS RESEARCH ON CONTROLLED THERMONUCLEAR REACTIONS. J. L. Tuck (Los Alamos Scientific Lab., N. Mex.). p.920-8 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Studies of energy loss from the toroidal pinch Perhapsatron S-4 reveal that this loss can be accounted for to within  $\pm 50\%$  by line radiation of highly ionized contaminant atoms of oxygen and silicon. It was found that pinch stability in Columbus S-4 can be increased by adding a negative longitudinal magnetic field between the pinch and the wall. Columbus S-5 was found to have stability times ( $\approx 8 \mu\text{sec}$ ) greater than the smaller Columbus S-4 ( $\approx 2.5 \mu\text{sec}$ ). Results from the two machines when normalized for change in radius, however, were in good agreement. A review of the Scylla experiment revealed some new findings: the region of neutron emission on fireball was re-mapped and the earlier results were confirmed. The neutron yield was measured with precise instrumentation, using standard silver counters. No evidence discordant with a thermonuclear reaction was found, and the results are hard to account for in any other way. A theoretical explanation of the mode of action of Scylla is made. The entropy method for trapping plasma at a high  $\beta$  (= plasma pressure/confining field pressure), which does not depend on instability or collisions, is given. (M.C.G.)

## 17522

HERMONUCLEAR WORK AT HARWELL, A BRIEF REVIEW. Gordon Francis (Atomic Energy Research Establishment, Harwell, Berks, Eng.). p.929-30 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Research at Harwell consists of experiments on Zeta and smaller scale investigations on selected problems in plasma physics. Modifications to Zeta and their results are reported. Propagation velocity and damping of Alfvén waves were measured. Stabilities of pinched and unpinched discharges were compared. Shock heating of a toroidal pinched discharge was studied. Work is now being done on pre-heat measurements and plasma containment in cusped geometry. (M.C.G.)

## 17523

THE ENERGY LOSS PROBLEM WITH SCEPTRE IIIA. A. A. Ware (Associated Electrical Industries, Ltd., Aldermaston, Berks, Eng.). p.931-6 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

One of the main problems in the study of the pinch effect in high current discharges is to explain the high rate of

loss of energy by the electrons. A review is given of recent spectroscopic, magnetic probe, x ray and other measurements which have been made on the toroidal pinch experiment, Sceptre IIIA, to determine the mechanism of the energy loss. A theory is put forward which gives such a mechanism and which accounts for several other previously unexplained properties of the discharge. (auth)

## 17524

THE MEASUREMENT AND INTERPRETATION OF THE MAGNETIC FIELDS IN SCEPTRE IIIA. N. L. Allen and B. S. Liley (Associated Electrical Industries, Ltd., Aldermaston, Berks, Eng.). p.937-43 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Measurements of the magnetic fields were made in Sceptre IIIA. From these, current densities, electric fields, electron temperature, and pressure distributions were determined. In interpreting these results an explanation for the enhancement of the "axial" magnetic field is given, while the magnitude of certain "loss" mechanisms was estimated. (auth)

## 17525

PLASMA RESEARCH AT A.E.I. RESEARCH LABORATORY, ALDERMASTON COURT. D. R. Chick (Associated Electrical Industries, Ltd., Aldermaston, Berks, Eng.). p.944-6 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

It is estimated that about 25% of the stabilizing flux threading the Sceptre IIIA torus bore at the center of a sector passes into the copper liners used to shield the sector gaps. Electron currents of several thousand amperes flow to these liners which are also the predominant source of kilovolt x rays. In order to minimize losses resulting from such a field configuration and in an attempt to extend the studies to higher currents, a new apparatus known as Sceptre IV was planned. Thus the required stabilizing field configuration is precisely defined and care was taken to keep this field everywhere parallel to the toroidal torus wall. The apparatus is designed to produce currents of up to 800 ka in a toroidal pinched discharge, a d-c magnetic field being provided for stabilizing the discharge. The torus mean diameter of 2 m, bore of 0.3 m is made up, from 24 copper sectors, insulated with vacuum-tight porcelain rings and pumped through a single port by an oil diffusion pump. The stabilizing magnetic field is provided by 48 coils, water-cooled and supplied from a heavy current rectifier set of 10,500 amp peak output. The primary coil is wound outside the d-c coils and can be connected to give either 8, 16, or 32 turns ratio. To reduce the primary magnetizing current required, the torus and windings are assembled round an iron core, diameter 1.1 m, weight 54 tons. The discharge current is induced by switching the primary to a capacitor bank of  $10^6$  joules energy storage at 24 kv. The capacitor can be charged once every 10 seconds by a valve rectifier set and ignitron valves are used for switching the energy into the primary. Facilities are provided on the discharge tube for spectroscopic, probe, and nuclear measurements, and for radiation shielding the whole apparatus is enclosed in water tanks. (auth)

## 17526

INVESTIGATION OF A TOROIDAL DISCHARGE IN A

**STRONG MAGNETIC FIELD.** G. G. Dolgov-Saveliev, V. S. Mukhovatov, V. S. Strelkov, M. N. Shepelev, and N. A. Yavlinski (Academy of Sciences, Moscow). p. 947-53 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

This paper was previously abstracted from the original language and appears in *NSA*, Vol. 14, as abstract No. 14519.

### 17527

**MAGNETIC FIELD CONFIGURATIONS IN TOROIDAL DISCHARGES.** D. J. Lees and M. G. Rusbridge (Atomic Energy Research Establishment, Harwell, Berks, Eng.). p. 954-60 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

A method of analysis of magnetic probe data in conjunction with gas current measurements is described, and applied to results from Zeta and a smaller torus of similar design. It is shown that reversed axial field must appear outside the discharge and that it is unlikely that this can be accounted for as the result of helical distortion of the current channel. It is also found that in some cases the inter-diffusion of the magnetic fields takes place in a time shorter by at least an order of magnitude than that expected on the basis of the measured electron temperature; other cases have been observed in which the diffusion time is of the right order of magnitude. (auth)

### 17528

**A TOROIDAL FAST PINCH EXPERIMENT.** D. E. T. F. Ashby and J. W. M. Paul (Atomic Energy Research Establishment, Harwell, Berks, Eng.). p. 961-6 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

An experiment is described in which an axial skin current is produced in a toroidal plasma containing an axial magnetic field. This current sheath collapses at a high velocity producing a hydromagnetic shock. After reflection from the axis of the tube the shock meets the current sheath and causes adiabatic radial oscillations of the discharge. These are described by a simple hydromagnetic theory and information about the discharge derived. (auth)

### 17529

**EXPERIMENTS WITH T.A. 2000.** C. Etlevant, P. Ginot, P. Hubert, P. Rebut, B. Taquet, and A. Torossian (Commissariat à l'Énergie Atomique, Fontenay-aux-Roses, France). p. 967-71 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

T.A. 2000 is an all metal torus designed for experiments on conventional "stabilized" pinch. Predischarge technique was established from experiments on breakdown requirements. Time and space distributions of x rays related with breakdown were obtained by photomultipliers and photographic techniques, respectively. Magnetic probing reveals a reproducible mean configuration which is destroyed when the current decreases. (auth)

### 17530

**SPECTROSCOPIC STUDIES ON T.A. 2000.** C. Breton and

L. Herman (Commissariat à l'Énergie Atomique, Fontenay-aux-Roses, France). p. 972-7 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The light emission in the quartz ultraviolet and visible region of a toroidal discharge in hydrogen at the pressure of  $5 \times 10^{-4}$  mm Hg was studied. It is found, that (under present working conditions) only a small amount of impurities are introduced in the plasma from the walls. The lines identified so far are those of the Balmer series  $H_\alpha$ ,  $H_\beta$ ,  $H_\gamma$ , and some of CII, CIII, CIV, OI, OII, and OIII. From the width of CIII,  $\lambda = 2296$ , 9 Å line, ion temperature of the order of 400,000°K could be derived under assumption of thermal distribution. The variation of the  $H_\beta$ , CIII,  $\lambda = 4653$  Å and CII,  $\lambda = 4267$  Å line intensities indicates that the electron temperature at the maximum current amplitude does not exceed 100,000°K. The spectral line intensity variation with time was followed by means of photomultiplier and an oscillograph. An interpretation of the results according to the theory of the solar corona allows to make conclusions on the electron temperature existing at a given instant. The widths of several spectral lines were measured and an ion temperature deduced, assuming that the line broadening is due only to the thermal Doppler effect. However, as it will be discussed later, plasma oscillations seem to contribute largely to the line broadening. (auth)

### 17531

**HIGH CURRENT TOROIDAL DISCHARGE IN He.** K. Yamamoto, S. Miyajima, K. Hasebe, K. Nobata, T. Okuda, S. Maeda, S. Nagai, and K. Yoshihara (Nagoya Univ., Japan). p. 978-80 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Recent mirror machine experiments at the Lawrence Radiation Laboratory were concerned primarily with (a) studies of injection methods, (b) investigation of diffusion and non-adiabatic loss processes, and (c) with further attempts to analyze the energy distributions of trapped and heated plasma particles. Some results of these studies are reported in the following categories: (1) Studies of the trapping of energetic plasma streams, with respect to the particle density and the angular distribution of the trapped ions. (2) Experiments preparatory to the generation and proposed trapping of intense neutral atom beams in a mirror machine (the ALICE experiment). (3) Measurements of the distribution in radius and the rate of diffusion loss of the high energy electron component of a heated plasma produced by magnetic compression. These results are reviewed in the light of the general objectives of the Livermore Mirror Machine Program. (auth)

### 17532

**THE DCX APPROACH TO THE THERMONUCLEAR PROBLEM-PROGRESS SINCE GENEVA.** Arthur H. Snell (Oak Ridge National Lab., Tenn.). p. 997-1001 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

A current of 3 ma of 600 kev  $H_2^+$  ions is now injected into DCX for dissociation and trapping of  $H^+$ . The mean residence time and the density of the trapped plasma are still about 6 ms and  $10^9$  to  $10^{10}$   $H \text{ cm}^{-3}$ , respectively, at  $10^{-6}$  mm Hg. Below about  $5 \times 10^{-6}$  mm Hg, the trapped plasma

spreads and may occupy a volume about 35 cm long and 37 cm in diameter, with apparent orbital mixing. The vacuum carbon arc used to dissociate the primary  $H_2^+$  ions itself furnishes a loss mechanism by charge exchange, and has to be used with circumspection. At  $10^{-6}$  mm Hg, about half of the charge-exchange loss is in the arc, and half in the residual gas. About half of the trapping rate of  $H^+$  ions can then be accounted for by peripheral charge exchange in arc and gas. Plans are under execution to reduce the arc loss by introducing orbital precession for the  $H^+$  particles. (auth)

17533

TRAPPING OF HIGH-ENERGY IONS WITHIN AN ARC WALL. John Sidney Luce (Oak Ridge National Lab., Tenn.). p.1002-8 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

No basic limitation was encountered in producing large cylindrical carbon arcs and trapping high-energy ions inside the wall of the arc. The role of this system in the field of controlled fusion research is dependent upon success in producing ions in the arc with high average charge, the elimination of low-energy neutrals, and the establishment, of the trapped ions in orbits well inside and away from the walls of the arc. Proper evaluation of the system will be made when the decay time of the trapped ions is measured. (auth)

17534

MEASUREMENT OF THE LIFETIME OF A LOW DENSITY PLASMA IN A MAGNETIC MIRROR TRAP. M. S. Ioffe, R. I. Sobolyev, V. G. Telkovskii, and E. E. Yushmanov (Academy of Sciences, Moscow). p.1009-14 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The lifetime of a hydrogen plasma of density  $10^9$  to  $10^{10}$   $cm^{-3}$  in a cylindrical magnetic trap was studied in the present work. The ion energy in the plasma was several kev and the mean electron energy of the order of 10 ev. In the presence of the plasma the residual hydrogen pressure was  $3 \times 10^{-7}$  mm Hg. The lifetime was determined by measuring the flux of fast neutral particles produced as a result of charge exchange of the ions. It was found that under the conditions of the present experiment fast ions escape from the trap at a greater rate than would be expected on the basis of charge exchange and scattering of the ions. (auth)

17535

ESTIMATING THE LIFETIME OF IONS IN A MIRROR MACHINE. H. N. V. Temperley (Atomic Weapons Research Establishment, Aldermaston, Berks, Eng.). p.1015-16 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

A model of a mirror machine is described which consists of two or more portions connected stepwise, in each of which the trajectory of an ion can be computed analytically, the object being to reduce the pile-up of errors that occurs if a long trajectory is computed step-by-step. In addition, the model can be handled by wave-mechanics, and lifetimes estimated, in a manner analogous to that of the Gamow theory of radioactive decay. The model is based on

the fact that both the classical and wave-mechanical solutions of the motion of a charge in the field of a magnetic pole are known. (auth)

17536

INVESTIGATIONS OF MAGNETIC TRAPS WITH SPACE-CHARGE. K. D. Sinelnikov, B. G. Safronov, V. D. Fedorchenk, B. N. Rutkevich, and B. M. Cherny (Academy of Sciences, Ukrainian SSR, Kharkov). p.1017-20 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The case considered is one in which a charged particle will change its magnetic moment while passing along a slightly modified mirror machine. The magnetic moment of a particle influenced by a space-modulated field may not only increase but also decrease, and a system used for trapping particles allows them to escape in due time. This circumstance limits, but does not exclude, the possibility of a limited accumulation of particles. The decrease of the magnetic moment was also observed under special conditions of particle injection into the system. Both methods indicate the formation of negative space charge which can serve as a potential trap for the ions. (M.C.G.)

17537

RECENT PROGRESS IN SHOCK WAVE RESEARCH. Alan C. Kolb (U. S. Naval Research Lab., Washington, D. C.). p.1021-31 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Research on the production of temperatures in excess of 30,000° by means of shock processes has concentrated on the utilization of electromagnetic forces to accelerate ionized gases. A T-type electromagnetic shock tube is used at the Naval Research Laboratory to produce plasmas in a high state of ionization at high temperatures. Streak camera photographs of the shock velocities and planarity of the shock front were made. The electron density was determined from time-resolved streak spectra of the shock front. For a given velocity of the primary shock wave, still higher temperatures and densities can be reached by the collision of two strong electromagnetically driven shock waves or by the collision of a shock wave with the end of the tube. Work has also been done on the production of plasma by cylindrical shocks. (M.C.G.)

17538

RECENT EXPERIMENTAL RESULTS ON FAST-COMPRESSION PLASMA HEATING AND ROTATING PLASMAS. F. L. Ribe (Los Alamos Scientific Lab., N. Mex.). p.1032-6 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Some of the results obtained at Los Alamos in connection with the Scylla and Ixion experiments since the 1958 Geneva Conference are reported. In the Scylla experiment spectral measurements give estimates of the electron and ion temperatures. In Ixion the diamagnetism of the rotating plasma was measured. (auth)

17539

DENSE PLASMAS CONFINED BY EXTERNAL FIELDS. A. C. Kolb, H. R. Griem, and W. R. Faust (U. S. Naval Re-

search Lab., Washington, D. C. and Univ. of Maryland, College Park). p.1037-41 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Neutrons, hard x rays, and continuous bremsstrahlung radiation in the soft x ray and visible regions were observed in dense plasmas confined by externally generated magnetic fields (magnetic mirror geometry). A comparison of recent experimental results on the confinement and heating with theoretical expectations will be presented, with emphasis on the effect of mirror losses on the plasma temperature and density. It was also demonstrated that the presence of reversed trapped magnetic fields drastically alters the discharge characteristics and leads to a mechanism for neutron production and the excitation of large amplitude radial oscillations. The experimental situation relevant to these effects will be reviewed on the basis of experiments now in progress. (auth)

#### 17540

ELECTRICAL DISCHARGE IN A MAGNETIC MIRROR CONFIGURATION. M. Alidieres, R. Aymar, C. Etlevant, P. Jourdan, and A. Samain (Commissariat à l'Énergie Atomique, Fontenay-aux-Roses, France). p.1042-5 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

A magnetic compression is performed on deuterium gas contained in a spherical chamber. The magnetic configuration without gas is a magnetic mirror configuration. Magnetic probes and high speed camera are used to follow the evolution of the system. It appears that the magnetic configuration may have various states, including a nonstabilized toroidal pinch configuration. Microwave and x-ray measurements are made. (auth)

#### 17541

EXPERIMENTS ON SHOCK-COMPRESSSION OF PLASMAS. Hermann Fay, Eduard Hintz, and Hermann L. Jordan (Technische Hochschule, Aachen). p.1046-9 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Experiments on the shock compression of plasma by fast rising externally generated magnetic fields were performed with a concentration on the early stages of the discharge. The experiments show that there is a fully ionized gas with high spectral purity generally until the third half-cycle. Following the first half-cycle large  $B_z$  signals are observed in the plasma with magnetic probes. During this time neutrons are emitted with a time duration of about 1  $\mu$ sec on the average without magnetic mirrors. Neutron emission is also observed at later times up to the sixth half-cycle, after the plasma has been contaminated by silicon and oxygen from the walls. (auth)

#### 17542

SOME PECULIARITIES OF INDUCTION GAS DISCHARGES. E. D. Andruckina, S. E. Grebenshikov, M. S. Rabinovich, M. D. Reiser, A. Ya. Safronov, and I. S. Shpigel (Lebedev Inst. of Physics, Moscow). p.1050-6 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Studies of induction discharges were made in order to: (1) investigate the phenomenon of "freezing" or "capture" of the magnetic flux, (2) ascertain the simultaneous localization of current and luminosity in the gas, (3) reveal the existence of a skin-effect, and (4) determine the role of shock waves in induction discharge over a wide frequency range. These experiments were carried out in axial-symmetric homogeneous and non-homogeneous magnetic fields. (M.C.G.)

#### 17543

ON C.T.R. RESEARCH AT A.W.R.E., ALDERMASTON. G. B. F. Niblett (Atomic Weapons Research Establishment, Aldermaston, Berks, Eng.). p.1057-60 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Research at A.W.R.E., directed toward the study of controlled nuclear fusion, encompasses the study of dense and dilute plasmas. The work on dense plasmas has been devoted to rapid heating by magnetic compression using the pinch effect. Present work is directed toward the design of a pre-ionization system which will provide a highly ionized conducting gas before application of the main discharge. The design of a mirror machine for studying low-density plasmas was recently begun at A.W.R.E., and a system of neutral particle injection is proposed. In connection with these studies, the cross section for the dissociation of molecular hydrogen ions by hydrogen has been measured. (M.C.G.)

#### 17544

AN EXPERIMENTAL INVESTIGATION OF THE RAPID COMPRESSION OF A PLASMA USING AZIMUTHAL CURRENTS (THETATRON). H. A. B. Bodin, T. S. Green, G. B. F. Niblett, and N. J. Peacock (Atomic Weapons Research Establishment, Aldermaston, Berks, Eng.). p.1061-4 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

An experimental study of phenomena accompanying the compression of a plasma by a rapidly-rising axial magnetic field is described. The field is produced by the discharge of a low inductance condenser bank (30 kev, 100  $\mu$ F, 5 m $\mu$ H) through a single turn coil, and peak currents of  $1.8 \times 10^8$  amperes and fields of  $1.1 \times 10^5$  gauss are recorded. High speed photography and electrical measurements are used to study the characteristics of discharges in air and deuterium. The mass of gas trapped by the current sheath is estimated from the measured frequency of radial oscillations of the plasma. X ray and neutron emission is observed from discharges in deuterium. Neutrons occur at peak current on the second and occasionally the third half-cycle and streak photographs show that the plasma is fluctuating rapidly at this time. (auth)

#### 17545

THE FORMATION AND IMPLOSION OF A CYLINDRICAL CURRENT SHEATH IN THETATRON. H. A. B. Bodin, T. S. Green, G. B. F. Niblett, and N. J. Peacock (Atomic Weapons Research Establishment, Aldermaston, Berks, Eng.). p.1065-72 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

During investigations of pinched discharges using azimuthal currents, it was observed that magnetic field diffuses into and is trapped within the imploding sheath. It is shown that the field diffuses in during the sheath formation time, and values for this time at different pressures in deuterium are deduced. It is also shown that these times and the observed breakdown conditions are consistent with a simple model for the growth of ionization in this type of discharge. Measurements are also reported of the pinch times in oxygen, deuterium and air as a function of pressure. The scaling of the time with the discharge parameters is found to agree with theoretical predictions. (auth)

17546

EXPERIMENTS ON THE ORTHOGONAL PINCH EFFECT. J. E. Allen and S. E. Segrè (Istituto di Fisica Piazzale delle Scienze, Rome). p.1073-80 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Some orthogonal pinch effect experiments are reported, which were carried out using a condenser bank of  $11.25 \mu F$  at 20 kev, the period of oscillation being  $35 \mu sec$ . Magnetic probe measurements were made of the spatial and temporal variations of magnetic field strength within the plasma. The design of a larger condenser bank is then discussed, which includes a multi-sector coil enabling a large voltage per turn to be developed. (auth)

17547

"SHOCK" WAVES IN RAREFIED PLASMA. R. Z. Sagdeev (Academy of Sciences, Moscow). p.1081-5 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

In the case of rarefied plasma, according to the Riemann solution for one-dimensional running waves, the profile of the flow will deform with time. A study was made to discover what occurs within the transitional layer, where the quasi-hydrodynamic approximation is inapplicable. Steady-state waves of a finite amplitude for cold plasma were studied under different initial assumptions. A combination of the Landau mechanism with the effect of a magnetic field, which returns ions to resonance with wave, represents the missing link which the dissipative effects needed to assure that the formation of shock waves might be obtained. (M.C.G.)

17548

COLLISION FREE MAGNETOHYDRODYNAMIC SHOCK WAVE. A. Kantrowitz, R. M. Patrick, and H. E. Petschek (Avco-Everett Research Lab., Everett, Mass.). p.1086-91 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Collisional dissipation in plasmas becomes extremely slow at high temperatures. It seems likely that other dissipative mechanisms associated with what has loosely been called "magnetohydrodynamic turbulence" will then become of prime importance. A shock wave propagating in a plasma where the cyclotron radius is much smaller than the mean free path provides a good opportunity to study these phenomena. It has been shown theoretically that such a shock wave must be thinner than a mean free path. A physical discussion of the shock structure is presented which explains the required dissipation in terms of the pro-

duction of a random distribution of magnetohydrodynamic waves inside the shock. Directed energy of the gas is first converted into wave energy and later into ordinary thermal motion of the particles. A discussion is given of the possibility of observing particles accelerated to high velocities by these waves. Experiments were performed using an electromagnetically driven shock wave which propagates in the annulus between two coaxial cylinders with an azimuthal magnetic field in the shock plane. The shock velocity and plasma density were obtained by measuring the bremsstrahlung intensity. Shock velocities were produced up to  $4.5 \times 10^7 \text{ cm/sec}$ . The kinetic energy corresponds to a temperature behind the shock of  $1.2 \times 10^{60} \text{ K}$ , density  $5 \times 10^{15} \text{ ions/cc}$ , mean free path 20 cm, and an ion cyclotron radius of 0.2 cm. Shock thickness obtained by measuring the time required for the continuum radiation to reach a steady value behind the shock was 2 cm. Shocks thinner than a mean free path could not be produced without a magnetic field in the plane of the shock. The observation of "thin" shocks confirms previous theoretical predictions and provides a powerful tool for the study of dissipative mechanisms in collision-free plasmas. (auth)

17549

CHARGE SEPARATION EFFECTS ON SHOCK WAVE STRUCTURE IN A PLASMA. O. W. Greenberg, H. K. Sen, and Y. M. Trève (Air Force Cambridge Research Center, Bedford, Mass.). p.1098-1104 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

A study of charge separation effects on the shock structure in a totally ionized hydrogen plasma was made using a simple kinetic theory model. In this model, the proton distribution function is a Mott-Smith distribution, and the electron distribution function is a Maxwell distribution. The shock structure is determined by the four conservation laws, the equation for the transfer of the square of the proton velocity component in the direction of flow, and Poisson's equation for the electric field. The transfer equation uses the Fokker-Planck collision term. These shock structure equations can be reduced to a pair of first order non-linear differential equations. A qualitative study of these equations shows that the proton and electron densities and the electric field have an oscillatory fine structure going through the shock. During the oscillations in the proton and electron densities, these quantities overshoot their final Rankine-Hugoniot condition values. The characteristic length for this fine structure is of the order of the Mach number,  $M$ , times the Debye length,  $\lambda_D$ . The distance in which the oscillations decay to  $1/e$ , which can be taken as the shock width, is proportional to the mean free path,  $\lambda$ , and varies as  $1/(M-1)$  for weak shocks, and  $M^4$  for strong shocks. The peak ratio of the electric field energy to the plasma thermal energy at the same point in the shock reaches 0.15 for a shock of Mach 1.8 in a plasma of  $\lambda/\lambda_D = 2 \times 10^4$ . The oscillatory fine structure found in this calculation is in qualitative agreement with an earlier hydrodynamic calculation of the present authors, and with a high order generalized Mott-Smith calculation done by Krook. (auth)

17550

METHOD OF STUDY FOR NON-IONIZING SHOCK WAVES. R. der Agobian (Université, Paris). p.1110-13 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959.

Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In French)

The detection of the non-ionizing shock waves is enhanced by creating on their path an independent auxiliary plasma. The optical survey and the radioelectrical exploration by a thin slice of said plasma makes it possible to detect the passage of the shock wave. The shock wave propagation study is plotted as a function of the experimental parameters of the discharge and compared with a theoretical calculation by Harris. The measurement of the plasma high frequency impedance exhibits a change in the electronic concentration and collision frequency of the electrons which increases with the wave velocity. (auth)

#### 17551

PARTICLE LOSS IN A STELLARATOR DURING OHMIC HEATING. R. A. Ellis, Jr., L. P. Goldberg, and J. G. Gorman (Princeton Univ., N. J.). p.1129-35 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The rates of particle loss from hydrogen discharges during ohmic heating in the B-3 stellarator were determined over a wide range of magnetic confining field and pressure. The observed loss rates are much faster than the predictions of classical collisional diffusion theory and are approximately proportional to  $B^{-\frac{1}{2}}$  rather than  $B^{-2}$ , where B denotes the confining field. When stabilizing helical windings were added to the B-3 stellarator in order to create a hydromagnetically stable configuration, the high loss rates persisted. It is concluded that the observed high loss rates are not due to hydromagnetic instabilities. An energy loss phenomenon has been identified which manifests itself by a limitation of the current. It is shown that this current limitation occurs when the discharge conditions may be conducive to electron runaway. The interpretation of these results as evidence for a possible electrostatic instability is given. (auth)

#### 17552

THE SPECTROSCOPY OF IMPURITIES IN THE STELLARATOR PLASMA. Dirck Dimock (Princeton Univ., N. J.). p.1136-40 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The purity of a stellarator plasma is investigated with particular reference to carbon impurity by adding known amounts of methane to the hydrogen discharge and observing the change in intensity of C II and C III spectra. To interpret the results it is necessary to know the state of ionization of the carbon. From theoretical cross sections and known temperatures and electron densities it is shown that at the time of measurement most of the carbon is present as  $C^{2+}$ . From the observations one then obtains 0.1 to 0.03 carbon atoms per initial hydrogen atom, for various pressures and electric fields. Preliminary results have been obtained for oxygen introduced as carbon dioxide. The adsorption of the carbon dioxide introduces a complication. It is still possible to introduce a correction factor from the methane results and obtain an estimate of the oxygen normally present. In the particular discharge studied this is approximately 0.12 oxygen atoms per initial hydrogen atom. (auth)

#### 17553

A DYNAMICALLY STABLE CURRENT FILAMENT. V. S. Komelkov, Y. V. Skvortsov, S. S. Tserevitinov, and V. I.

Vasiliev (Atomic Energy Inst., Academy of Sciences, Moscow). p.1141-50 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The formation and development of a current filament appearing during the movement of a plasma jet in deuterium, hydrogen, and argon are discussed. Initial gas pressures ranged from 10 down to  $10^{-2}$  mm Hg. Maximum currents in the discharge reached 500 ka. The current period ranged from 20 to 300  $\mu$ sec. Plasma movement was studied by means of high-speed photography, magnetic probes, and spectral measurements. The following were established: the distribution of the current in the moving plasma jet, the existence of continuum radiation, the appearance of which in the spectral range studied coincided with the appearance of the current column, and a high stability of the current filament which is maintained throughout the half-period of the discharge. (auth)

#### 17554

ACCELERATION OF PLASMA. A. Dattner (Royal Inst. of Tech., Stockholm). p.1151-5 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

A gas discharge between two coaxial cylinders is studied with pulsed discharge current of the order of  $10^4$  to  $10^5$  amps. Acceleration of the plasma in the discharge is measured by means of photocells. The current distribution in the plasma is investigated with magnetic coils. The results are compared with calculations based upon a "snow plow" model of plasma motion and a fairly good agreement is found for the case of hydrogen. The velocity is found to be proportional to the cubical root of condenser voltage squared, divided by pressure. The current distribution exhibits two or more maxima, corresponding to two or more parallel plasma disks. (auth)

#### 17555

ELECTRODELESS GENERATION AND ACCELERATION OF PLASMA RINGS. L. Höglberg, K. Siegbahn, and K. Bocksten (Inst. of Physics, Uppsala). p.1156-9 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

A small apparatus is described, designed to study some properties of electrodeless generation and acceleration of plasma rings. Doppler shift measurements indicate that ion velocities of  $10^6$  to  $10^7$  cm/sec are obtained. Some interesting features were observed about the ignition mode of the discharge. (auth)

#### 17556

EXPERIMENTS WITH PLASMA BEAMS. E. R. Harrison (Atomic Energy Research Establishment, Harwell, Berks, Eng.). p.1160-3 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Some experiments are described in which a continuous discharge is used as a source of charged particles. At low pressures, of the order  $10^{-2}$  mm Hg, electron beams are drawn out of the discharge through a small diameter aperture into a longitudinal magnetic field. With a slightly increased pressure, the discharge acts as a source of small

diameter plasma beams; continuous current beams of up to several amperes were studied. On increasing the applied electric field the plasma beams are found to contain a large fraction of energetic or runaway electrons. When the pressure in the source is increased to 5 mm Hg, or more, a thermally constricted arc forms which ejects luminous anode rays consisting of ions of the cathode material having energies much greater than the maximum applied potential difference across the arc. Finally, with the source pressure raised to 10 cm Hg, or greater, a plasma jet is expelled which has luminosity variations caused by shock waves. (auth)

17557

**TOROIDAL MAGNETIC BOTTLE.** T. Ohkawa, G. Miyamoto, H. Yamato, and N. Matsuda (Univ. of Tokyo and Tokyo-shibaura Electric Co.). p.1164-70 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

The conditions which a magnetic field configuration must satisfy for confining charged particles in a topological torus are derived. Several examples of the configurations are given and the motions of particles are calculated according to the first order orbit theory. The simplest example is the configuration in which the lines of force consist of arcs and straight lines and are connected in such a way as to make a torus scalloped in both radial and axial directions. The motions of the guiding centers of particles can be described by linear transformations of positions of the centers up to the first order of the ratio of bore radius and major radius of the torus. The equilibrium conditions of rarefied plasmas in the configurations are also considered. The dipole charge separations can be eliminated by the scalloping in the radial direction and the remanent quadrupole by the scalloping in the axial direction of the torus. The higher order poles can be neutralized by making the torus figure eight shaped by changing the orders of connection of each arc section. A brief description of the design of the model under construction is also given. (auth)

17558

**VISCOUS EFFECTS IN HIGHLY IONIZED ROTATING PLASMAS.** W. R. Baker, A. Bratenahl, A. W. DeSilva, and W. B. Kunkel (Univ. of California, Berkeley). p.1171-5 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Rotating highly ionized plasmas may be generated in systems of cylindrical symmetry by passing a large radial current through a low density gas in an axial magnetic field. The rotation is hindered by contact with the stationary walls of the vacuum chamber. Under the simplifying assumptions of steady state laminar fluid flow and uniform viscosity, two extreme cases may be treated analytically. In the first, the flat disk approximation, the flow is considered to be controlled by axial shear alone. If zero slip is assumed to exist at the insulating surfaces which confine the plasma axially the current is shown to flow in a thin boundary layer, the thickness of which is of the order  $\delta = (1/B) \sqrt{(\mu/\sigma)}$ . Consequently, the electrical resistance of the plasma appears many times larger than in the absence of the magnetic field. It also follows that the speed of rotation of the plasma in this case should be inversely proportional to the distance from the axis. These conclusions are partially supported by experimental evidence. In the second

case treated analytically, the long cylinder approximation, only radial shear is considered important. In this case the current density is independent of the axial position. Here the apparent resistance is even higher because now all the current has to pass through regions of rapidly spinning plasma in whose frame of reference the electric field is very low. It is therefore practically impossible to construct a simple rotating plasma machine whose volume resistance is lower than the resistance along the end plates. In one obvious scheme to prevent the current from flowing near the insulators an attempt is made to keep the entire plasma from making contact with the insulator surfaces. The first of such models is briefly introduced at the end of this paper and the main results are summarized. (auth)

17559

**INVESTIGATION OF ION CYCLOTRON RESONANCE IN A DENSE PLASMA.** K. D. Sinelnikov, V. T. Tolok, N. I. Nazarov, I. I. Bakayev, V. A. Bondarev, and U. P. Bugay (Academy of Sciences, Ukrainian SSR, Kharkov). p.1176-80 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

An investigation of ion cyclotron resonance in a hydrogen plasma with a density of  $10^{12}$  to  $10^{14}$  cm $^{-3}$  was carried out under pulsed conditions. A direct current discharge in a longitudinal magnetic field up to 10 $^4$  gauss served as a plasma source. The dependence of high frequency energy transmission to the plasma on various parameters was measured. (auth)

17560

**THIN PLASMAS OF VARIABLE DENSITIES.** Lennart Simons (Univ. of Helsinki). p.1181-6 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

A plasma in an axial magnetic field, the density function of which is continually falling in the direction of increasing radius, with the density gradient being fixed and finite, is considered. It is observed that at every instant, and in every cross section perpendicular to the cylinder axis, the electron currents are in opposite directions, so that the total electron current equals zero. The currents thus change direction, every half period. The sheet current that arises at constant charge density is a special case depending on the fact that the density rapidly approaches zero at the plasma boundaries. Because of the ion motions, a magnetic field is induced which has different strength for ions at different distances from the axis. This phenomenon is due to the fact that the more remote ions have higher velocities. Instead of the original confinement field an inhomogeneous field thus arises. This initiates a phase difference for ions at different distances from the axis. This phase difference increases with time and may, if it is  $> 90^\circ$ , give rise to very effective impacts. For variable plasma density, the expression for this phase difference contains the same expression for the density gradient as does the expression for the electron current density. Thus there is a connection between the phase difference for ions at different distances and the electron current density. A specific consequence of this is that strong sheet current is followed by strong turbulence at the boundary. This is a well known fact which may also have other reasons. (auth)

17561

**OBSERVATIONS IN HIGH DENSITY PLASMAS PRODUCED**

BY EXPLODING WIRES. William G. Chase (Air Force Cambridge Research Center, Bedford, Mass.). p.1191-5 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In English)

Measurements were made of the behavior of the current during the vapor phase of wire explosions. It was found that current flow continued during the dwell or dark time, with a current density of about  $10^5$  amps per  $\text{cm}^2$ . High-speed photographs and flash x rays indicate a mechanism of vaporization from a highly superheated liquid. The density of the resulting vapor is of the order of  $10^{20}$  atoms per  $\text{cm}^3$  ( $0.5 \text{ g/cm}^3$ ), and its conductivity is intermediate between that of a "normal" gas and a plasma. The restrike or reignition is then shown to be caused by the onset of avalanching, not by conventional breakdown. Shock waves are, therefore, not necessary for restrike, but do determine the path. (auth)

#### 17562

CONCERNING PINCH-LIKE APPEARANCES IN EXPLODING WIRES. H. Bartels, P. Gansauge, and J. Bortfeldt (Technische Hochschule, Hanover). p.1196-8 of "Proceedings of the Fourth International Conference on Ionization Phenomena in Gases, Uppsala, 17-21 August 1959. Volume II." N. Robert Nilsson, ed. Amsterdam, North-Holland Publishing Company, 1960. (In German)

Streak camera photographs of exploding wires were made in hydrogen, helium, and air at various pressures. At pressures up to about one atmosphere the photographs show appearances similar to pinch: The cylinder of metal-vapor within the plasma is compressed by the magnetic pressure in every half-period and a shockwave runs in to the axis of the cylinder. In the axis a strongly light emitting filament appears, which thereafter radially runs out with a very sharp front. The occurrences in the explosion-plasma are also demonstrated on photographs of the emitted spectra. (auth)

## Shielding

#### 17563

THE ANGULAR AND ENERGY DISTRIBUTION OF  $\gamma$  RADIATION IN WATER AND IRON. Yu. A. Kazanskii. Atomnaya Energ. 8, 432-40(1960) May. (In Russian)

Multiple scattering characteristics and angular and energy distributions were studied in order to evaluate  $\gamma$  radiation attenuation in complex geometries of iron and water. The angular and energy distributions from a  $\text{Co}^{60}$  source in water and in iron were measured under semi-infinite conditions, and it is shown that the distribution maximum is found near the angle of minimum single scattering. The intensity distributions are of an exponential character; moreover, the exponential coefficient is a linear function of the atomic number of the medium. (tr-auth)

#### 17564

THE CONSTRUCTION OF REACTOR SHIELDING. J. Seetzen (Technische Hochschule, Hanover). Atomwirtschaft 5, 230-3(1960) May. (In German)

In the design and construction of reactor shielding space requirements, weight and cost must be considered. The theoretical fundamentals, the choice of construction materials, and the construction technology are discussed with respect to these considerations. (J.S.R.)

## Theoretical Physics

#### 17565

REGULARIZED VACUUM EXPECTATION VALUES IN QUANTUM FIELD THEORY. John W. Moffat (RIAS, Baltimore). Nuclear Phys. 16, 304-12(1960) May (1). (In English)

A formal method of regularizing vacuum expectation values of Heisenberg current operators is introduced by imposing certain conditions on the spectral functions. The method is applied to Källén's calculation of the vacuum-polarization in an external electromagnetic field and leads to results which are explicitly gauge-invariant. (auth)

#### 17566

SOME INTEGRAL REPRESENTATIONS IN FIELD THEORY. R. F. Streater (Imperial Coll. of Science and Tech., London). Nuovo cimento (10) 15, 937-48(1960) Mar. 16. (In English)

It is shown that the properties of positive mass and energy, and of causality lead in quantum field theory to problems in the theory of analytic completion. A representation for the double commutator previously proved the most general is stated, and its connection with analytic completion noted. A similar representation for the triple commutator is proved to satisfy causality and the positive mass and energy condition, but is not shown to give all the functions with these properties. A conjecture about the envelopes of holomorphy of domains occurring in the discussion of analytic properties of the four-point Green's function is made. Integral representations for the n-fold multiple commutator are proposed, and for some other combinations of Wightman functions. These representations lead to some results in analytic completion. (auth)

#### 17567

THE GAUGE PROPERTIES OF GREEN'S FUNCTIONS IN QUANTUM ELECTRODYNAMICS. S. Okubo (Università, Naples). Nuovo cimento (10) 15, 949-58(1960) Mar. 16. (In English)

Effects of a change of gauge on the Green's functions are studied systematically in quantum electrodynamics and relations between Green's functions under two different gauges are given. (auth)

#### 17568

EXAMPLE OF A SOLUBLE FIELD THEORY WITH FINITE CHARGE RENORMALIZATION. Herbert M. Fried (Univ. of California, Los Angeles). Phys. Rev. 118, 1427-9(1960) June 1.

A soluble field theory suggested by the Lee and Machida models is described in which coupling constant renormalization arises from a dressed boson and is finite if the contributing fermions are assumed nonrelativistic. For the unrenormalized charge to be real, the renormalized charge must satisfy a certain inequality depending on the boson and fermion mass ratios; if this inequality is violated a single boson ghost state occurs, as expected. (auth)

#### 17569

FORMAL MULTICHANNEL SCATTERING THEORY. AN ALTERNATIVE FORMULATION. Gerald Grawert (Universität, Göttingen, Ger.) and Joachim Petzold (Universität, Heidelberg, Ger.). Z. Naturforsch. 15a, 311-19(1960) Apr. (In German)

An alternative formulation is presented of the formal theory of multi-channel scattering in nonrelativistic quantum mechanics. The formulation is started by defining spaces of state vectors, where two particles either stay

together or separate in the limit  $t \rightarrow +\infty$  (or  $-\infty$ ), when the state vector develops in time by  $e^{-iHt}$  ( $H$  is the complete Hamiltonian of the  $n$ -particle system). A channel is defined as a space of state vectors with the following property: developing in time by  $e^{-iHt}$  they asymptotically describe a state of the  $n$ -particle system, where the particles are grouped in fragments. Defining a Hamiltonian  $H_y$  for each channel, in which—compared to  $H$ —the interactions acting between particles from different fragments are missing, it is physically plausible that  $\lim e^{-iH_y t} e^{-iHt} \Psi$  exists for vectors  $\Psi$  in the channel. Having discussed the limit vectors (asymptotic states), the S-matrix formalism can be introduced as usual. Finally, the introduction of the exclusion principle is discussed. (auth)

17570

OSNOVY TEORII ATOMNOGO IADRA. (Fundamental Theory of Atomic Nucleus). V. V. Malyarov. Moscow, State Publishing House for Physics of Mathematics, 1959. 472p.

Lectures on theoretical nuclear physics presented at the Mechanikov Odessa State University have been compiled and are presented as a text. The text incorporates all phases of theoretical nuclear physics including the latest data. 371 references. (R.V.J.)

17571

TEORIIA ATOMNOGO IADRA. (The Theory of Atomic Nucleus). A. S. Davydov. Moscow, State Publishing House of Literature on Physics and Mathematics, 1958. 611p.

An expanded series of lectures presented at Lomonosov Moscow State Univ. is presented. The problems of nuclear theory at energies not exceeding hundreds of Mev are analyzed. Nuclear models, the generalized nuclear model and problems related to nonspherical shapes, rotation and oscillation levels considering the state of individual nucleons, the general nuclear reaction theory, the optical model of nuclear interactions, the theory of nuclear stripping and capture reactions, the theory of direct and surface interactions, and the theory of pulse approximation are discussed as well as the theory of angular distribution and polarization of nucleons scattered by nuclei. Interactions of electromagnetic emission with nuclei, the theory of beta decay, and a series of other problems are also studied. However, phenomena related to meson production and absorption are not discussed. Certain problems and postulations are included which have not previously appeared in published literature. 433 references. (R.V.J.)

## REACTOR TECHNOLOGY

### General and Miscellaneous

17572 CNC-27

Italy. Comitato Nazionale per le Ricerche Nucleari, Rome. BURN-UP PROGRAM FOR A TWO-CORE CONVERTER REACTOR. D. Baroncini. Mar. 1960. 69p.

A one-group model is presented for the treatment of the reactivity lifetime problem in a two-region reactor. The inner region is designed for the  $\text{Th}-\text{U}^{233}$  conversion, while the outer region is fueled with natural uranium. A generalization of non-uniform burnup for a single-region thermal power reactor is presented, as a first approach to a non-uniform treatment for the lifetime study of the two-region reactor. (W.D.M.)

17573 HW-50137

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

REACTOR EFFLUENT MONITORING. R. B. Hall. May 8, 1957. Decl. May 4, 1960. 10p. Contract W-31-109-Eng-52. OTS.

A discussion of the reactor effluent monitoring problem, permissible limits, and principles of control is presented. Proposals to improve monitoring for both control and inventory purposes are discussed. (C.J.G.)

17574 HW-61391

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

SUGGESTED MAJOR EQUIPMENT FOR NPR WATER QUALITY CONTROL LABS. W. D. Bainard. July 30, 1959. 4p. Contract AT(45-1)-1350. OTS.

Hot and cold water control laboratories designed for use in conjunction with NPR are described. Major equipment suggested for inclusion in the laboratories is listed. (J.R.D.)

17575 HW-62551

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

DESIGN TEST PR-20 CALANDRIA CHARACTERISTICS; FINAL REPORT. R. L. Gruver. Oct. 30, 1959. 9p. Contract AT(45-1)-1350. OTS.

The performance of the calandria under transient conditions was investigated, and moderator drop of 70 in. using 4, 3, and 2 dump valves is reported. The maximum rate of rise of the  $\text{D}_2\text{O}$  moderator was recorded to assist in determining the increase in reactivity during filling. The rate of increase of the water level in the calandria was found to be dependent on the amount of water in the storage tank at the beginning of the filling operation. The available volume was changed by a factor of 2 and 3 and the effects of this variation were recorded. The height of moderator in the calandria had a marked effect on the power of the reactor. Therefore, the amount of surface disturbance caused by the various system variables was investigated. When the natural frequency over the height of the moderator was approached by a mechanism such as a pump that was near to or a part of the system, surface disturbances of  $\pm 0.15$  in. resulted. (M.C.G.)

17576 HW-62911

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

ION EXCHANGE RESINS AND WATER CONDITIONING METHODS EMPLOYED AT 1706-KER FOR THE IN-REACTOR LOOPS. M. L. Mutch. Dec. 1, 1959. 9p. Contract AT(45-1)-1350. OTS.

The various resins utilized in the 1706-KER facility were effective in maintaining high-purity, oxygen-free water at the desired pH for use in the KER in-reactor loops. The processes of water conditioning for loop make-up, special conditioning for loop clean up, and the utilization, specifications, and performance of resins were studied. Duolite S-10 resin was found to have a tendency to clump which was eliminated by treatment with acid followed by caustic or a mild oxidant. By using only technical grade chemicals for regeneration of the Duplex and Mixed Bed Deionizers, operating difficulties caused by certain contaminants in low-grade regenerant chemicals were minimized. Longer service was obtained from the Nuclear Grade Resins used for loop water cleanup and pH control by regenerating depleted lithium base resin with dilute LiOH and eliminating

unnecessary depletion of the resin due to valve malfunctions. (M.C.G.)

**17577** NAA-SR-Memo-3787

Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.

OCR STEAM GENERATOR BY-PASS ORGANIC FLOW CONTROL. R. F. Audette. Apr. 21, 1959. 8p. OTS.

Studies were made to determine a valve control scheme for the proposed OCR by-pass configuration which will provide smooth and accurate control of by-pass flow range. Two schemes using the same valves were considered and compared in their ability to produce the desired control characteristics. In the first of these, Scheme A, the two valves operate independently of each other, the main valve being operated in incremental steps as a programmed function of flow demand with the auxiliary valve used for linear control between the main valve step increments. In the second scheme, Scheme B, the main valve is also operated in incremental steps, but as a function of limit switches on the auxiliary control valve. By-pass flow is controlled by the auxiliary valve until the full open or closed limit is reached at which point the main valve is stepped one increment equal to half the auxiliary valve capacity. (W.L.H.)

**17578** NAA-SR-Memo-5054

Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.

BIBLIOGRAPHY OF REPORTS ON FAST REACTOR TECHNOLOGY. B. R. Hayward and M. Bloomfield. Mar. 23, 1960. 11p. OTS.

A bibliography is given of reports in the major fields of fast reactor technology. These fields are: fuels and materials, reprocessing, general technology, safety, and physics. 131 references are cited. (B.O.G.)

**17579** ORNL-2725(Rev.)

Oak Ridge National Lab., Tenn.

SAFEGUARD REPORT ON THE PROPOSED METHOD OF ANNEALING GRAPHITE IN THE X-10 REACTOR. L. E. Stanford, M. C. Wittels, M. E. Ramsey, and C. D. Cagle. May 18, 1960. 150p. Includes Appendices I-VI. Contract W-7405-eng-26. OTS.

The ORNL Graphite Reactor moderator has undergone approximately 16 years of almost continuous irradiation. Throughout this time stored energy has accumulated at a slow rate to the present maximum value of about 35 cal/gm releasable to 250°C. A small portion of the moderator (approximately 4%) contains stored energy which under adiabatic conditions may be released spontaneously (at approximately 165°C) to produce a maximum temperature of 270°C. Careful analysis has shown that the present condition is not hazardous; however, it appears wise at this time to initiate some corrective action (thermal annealing) to prevent the continued buildup of stored energy to a dangerously high value. Several methods of obtaining effective annealing in the ORNL were investigated. The proposed method was selected upon the basis of convenience, over-all safety, effectiveness, and cost. The proposed method involves the alteration of the present coolant flow system to permit reversal of air flow through the fuel channels. This will result in a reversed temperature distribution wherein the maximum graphite temperature will occur in the normally cold, maximum-stored-energy region of the moderator.

Such an arrangement permits an annealing operation to be performed under conditions very similar to those of the normal safe operation. The proposed procedure re-

quires a slow heatup of the moderator under full reversed, air-flow conditions. This can be accomplished by slowly raising the reactor nuclear power level until the desired graphite temperature is attained. During the initial stages of the operation, the stored energy will be reduced to a sufficiently low value that spontaneous energy release is no longer possible. This can be accomplished at temperatures (less than 140°C) well below the minimum (165°C) required for spontaneous energy release. Subsequent higher temperature may then be employed to further reduce the stored energy. Recurrence of stored energy which may be released spontaneously can be prevented by periodic annealing at rather infrequent intervals. (auth)

**17580** Y-715

Nuclear Development Associates, Inc., White Plains, N. Y. NUMERICAL INTEGRATION OF CRITICALITY EQUATIONS AND USE OF PERTURBATION THEORY FOR BARE Be-U<sup>235</sup> REACTORS. Stanley Preiser. Jan. 30, 1951. Decl. Jan. 28, 1960. 20p. For Oak Ridge National Lab., Y-12 Area. Contracts W-7405-eng-26 and AT(40-1)-1065. OTS.

A critical survey of the U investments required for bare, homogeneous, Be-U<sup>235</sup> spherical reactors, ranging in radius from about 35 cm to 100 cm, is presented. The effect of xenon poisoning, tabulated quantities useful in finding the poison coefficient for an absorber of arbitrary cross-section, and computed poison coefficients for 1/v absorber in general, and for Be in particular, are included. These results can be used as a starting point for criticality calculations when the change in density due to a coolant must be considered, and for introducing reflector savings by conventional two-group methods. The method of calculation employed here is outlined in TAB-96, and the essential data used was taken from NEPA-949-EAR-R6. (J.R.D.)

**17581**

INVERSE FLOW IN GAS-COOLED REACTORS. H. Benzler (Deutsche Babcock & Wilcox-Dampfkesselwerke AG., Oberhausen, Ger.). Atomkernenergie 5, 165-72(1960) May. (In German)

In a gas-cooled reactor with downward coolant flow, recirculation may occur in some cooling channels. It is shown that there is a rather broad region of partial load, in which inverse flow is selfsustaining. However, in the larger part of that region a normal downward flow cannot change to the adverse direction. (auth)

**17582**

THE USED FUEL RODS OF THE FIRST SOVIET NUCLEAR POWER STATION. A. P. Smirnov-Averin, V. I. Galkov, Yu. G. Sevast'yanov, N. N. Krot, V. I. Ivanov, I. G. Sheinker, L. A. Stabenova, B. S. Kir'yakov, and A. G. Kozlov. Atomnaya Energ. 8, 446-7(1960) May. (In Russian)

Fuel rods were analyzed following 104 effective days of operation and 1160 days of cooling. The mean swelling along the length of the fuel rod was from  $14.11 \pm 0.02$  to  $14.20 \pm 0.02$  mm. Burnup was determined by Cs<sup>137</sup> yield, measured by  $\gamma$  and  $\beta$  spectrometers. The mean burnup of U<sup>235</sup> as the result of neutron capture was 12.5%. The  $\alpha$ ,  $\beta$ , and  $\gamma$  activities along the rod were plotted. The contents of Pu<sup>238</sup>, Pu<sup>239</sup>, Pu<sup>240</sup>, and Am<sup>241</sup> isotopes along the rod were determined and tabulated. (R.V.J.)

**17583**

THERMAL SHOCK CALCULATIONS FOR REACTOR STRUCTURES. Yu. E. Bagdasarov. Atomnaya Energ. 8, 452-4(1960) May. (In Russian)

Rapid drops of coolant outlet temperature during emergency scrams creates a thermal shock in reactor walls. A protective thermal screen (usually made of the same material as the wall) is designed between the wall and coolant in order to protect the most important reactor parts. Analytical formulas are derived for evaluating the thermal shock for linear and exponential variations of  $\Theta(\tau)$  in fast sodium cooled reactors. (R.V.J.)

## 17584

FIRST FLIGHT COLLISION PROBABILITY IN LATTICE SYSTEMS. Hiroshi Takahashi (Japan Atomic Energy Research Inst., Tokyo). *J. Nuclear Energy, Pt. A, Reactor Sci.* 12, 1-15(1960) May.

The first flight collision probability in a slab lattice is often used to simplify the calculation of the fast fission factor  $\epsilon$  and the resonance escape probability  $p$ . Lattice cells of cylindrical rods, arranged in triangular, square, or hexagonal lattice form, are approximated by an equivalent circular cylindrical cell, and the first flight collision probability of such a cell is discussed by three methods. The first is a method due to Weinberg, the second is a modified spherical harmonics  $p_N$  approximation, and the third is an exact method for this lattice cell. The first flight collision probability in a particular rod lattice is calculated by both the equivalent slab and circular lattice approximations, and the numerical results are compared. (auth)

## 17585

SOME CALCULATIONS ON THE NEUTRON FLUX DEPRESSION IN THIN ABSORBING SLABS. M. Angelopoulos (Technical Univ. of Athens) and R. E. Strickland (Imperial Coll. of Science and Tech., London). *J. Nuclear Energy, Pt. A, Reactor Sci.* 12, 21-5(1960) May.

Calculations are given for the linear extrapolation length and the flux depression in absorbing and scattering slabs surrounded by a weakly absorbing moderator. Simple expressions are obtained if elementary diffusion theory is supposed to apply within the moderator and the multiple collision method is used in the slab. Numerical results which refer to a slab of natural uranium are compared with those calculated on the assumption that diffusion theory holds throughout the geometry. (auth)

## 17586

RESONANCE ESCAPE PROBABILITIES IN CIRCULAR CYLINDRICAL CELL SYSTEMS. Hiroshi Takahashi (Japan Atomic Energy Research Inst., Tokyo). *J. Nuclear Energy, Pt. A, Reactor Sci.* 12, 26-31(1960) May.

An investigation was made on the resonance escape probability in a circular cylindrical cell system, an approximation of an actual rod lattice. The analysis is based upon the integral form of the Boltzmann transport equation appropriate to this system. The resonance escape probability is evaluated and compared with the value for the slab lattice model obtained by Corngold. The resonance absorption in the cylindrical cell is found to be lower than in the slab system for a particular uranium-light water lattice. It is concluded that the resonance absorption given by the slab lattice approximation is an over-estimate. (auth)

## 17587

SOME STRENGTH PROBLEMS OF NUCLEAR REACTOR PRESSURE VESSELS. Jan Dvořák (State Inst. of Thermal Tech., Prague). *Jaderná energie* 6, 146-9(1960). (In Czech.)

Additional stresses in the walls of pressure vessels are caused by changes of wall thickness, of the radius of the

cylindrical parts, by the changes in the joining parts between the mantle and the bottom of the vessel, by unequal temperature distribution, etc. Some influences causing additional stresses, and methods of calculating additional stresses are indicated. (auth)

## 17588

THE SELECTION OF COOLANTS FOR HEAT TRANSFER AND UTILIZATION IN REACTORS. M. A. Zimin. *Kernenergie* 1, 248-51(1958) Apr. (In German)

A study was made of the conditions for selection of reactor coolant input and output temperatures. The coolant temperature at the outlet of a reactor (either power or multipurpose, i.e., power and Pu production) is determined by the allowable temperature of the canning material of the fuel elements. The coolant inlet temperature for a power reactor is based on the steam production parameter, while in the multipurpose reactor it is based on the temperature of the cooling water in the condensers or the melting point of the coolant in the case of liquid metal cooling. In this connection a study was made of the magnitude of the thermal efficiency, which is always higher in power reactors than in multipurpose reactors. In spite of the lower thermal efficiency, the total power produced in a multipurpose reactor differs only slightly from that produced in a power reactor. If, however, the power reactor is designed for extreme heat fluxes, it is more advantageous than the multipurpose reactor since for equal thermal capacities it can produce greater quantities of electricity. (tr-auth)

## 17589

REACTOR RADIAL SPATIAL BEHAVIOUR. R. L. Carsairs and R. W. Taylor (General Electric Co., Ltd., Erith, Eng.). *Nuclear Power* 5, No. 50, 120-2(1960) June.

The mathematical basis for a harmonic-perturbation analysis of the radial spatial behavior of a controlled reactor is presented with a one-group neutron-diffusion equation as the starting point. Control rod movement is allowed for, and the resulting equations can be used to study disturbances and long term effects such as xenon poisoning. (D.L.C.)

## Power Reactors

## 17590 ANL-6137

Argonne National Lab., Ill.

SOME STEADY-STATE THERMAL CHARACTERISTICS OF A THREE-LOOP REACTOR POWER SYSTEM. T. R. Bump and H. O. Monson. Mar. 1960. 22p. Contract W-31-109-eng-38. OTS.

The three-loop power system which is to be used with Experimental Breeder Reactor No. II (EBR-II) was analyzed to determine the coolant flow rate requirements at various power levels, coolant temperatures at various power levels, effects of heat exchanger sizes (system optimization), and effects of control errors. An intermediate heat exchanger, preheater, evaporator, and superheater are included in the EBR-II power system. Constant thermal resistances and physical properties, and perfect insulation were assumed in the analysis. Among other things, the study showed that at low power levels, excessive thermal stresses are produced at the cold end of the intermediate heat exchanger unless a high sink temperature is used. It was also found that a short cut may be used to determine approximate system conditions at all power levels, that system optimization requires compromises, and that system flow rate control is possible through high-low measurements of two coolant temperatures in the primary system. (auth)

**17591 APAE-47**

Alco Products, Inc., Schenectady, N. Y. and Alco Products, Inc., Fort Belvoir, Va.

ANNUAL REPORT, FEBRUARY 1958-FEBRUARY 1959. June 30, 1959. 75p. Contract AT(30-3)-326. OTS.

Plant operation and maintenance are reviewed and analyzed, and certain recommendations for improvements are made. The in-plant training program is described, and comments deemed appropriate are made. Plant accounting is outlined, and comments are made on plant costs. Unitization and property records and spare parts stocks accounting systems are described. Research and development tasks completed or in progress are reviewed, and conclusions and recommendations are made. The maintenance and instruction manuals for the SM-1 are being revised and rearranged to serve as a guide for other pressurized water plants of this general size. (auth)

**17592 APAE-58**

Alco Products, Inc., Schenectady, N. Y.

TASK XV-ZERO POWER EXPERIMENTS FOR THE SM-1 CORE II. R. A. Robinson, S. H. Weiss, W. J. McCool, and E. W. Schrader. Mar. 15, 1960. 51p. Contract AT(30-3)-326. OTS.

An element by element reactivity check for SM-1 Core II fuel elements and control rod absorber sections was performed and the burnable nuclear poison loading in the SM-1 Core II stationary fuel elements was established. An approach to criticality of the SM-1 Core II was performed by the inverse multiplication method and the critical rod bank position obtained as a function of fuel loading up to the full SM-1 Core II loading. Maximum and minimum core reactivity measurements were obtained by selective loading of stationary fuel elements and the total "excess K" for the core established. Power distribution measurements in the region of the core-reflector interface and the fuel-absorber interface in the control rod assemblies were performed. The effectiveness of europium flux suppressors in the top of control rod fuel elements and the power peaking in stationary elements adjacent to water gaps in control rod assemblies were measured. Survey measurements established the worth of spiking cold clean SM-1 cores with SM-2 elements, and of water holes in the SM-1 core which might be utilized as flux traps for materials irradiation. (auth)

**17593 APAE-Memo-239**

Alco Products, Inc., Schenectady, N. Y.

THERMAL STRESS TESTING OF SM-2 FUEL ELEMENTS. Interim Technical Report [for] January 1, 1959 to January 1, 1960. J. A. Christenson. 94p. Contract AT(30-3)-326. OTS.

Thermal stress testing was performed on two fuel plates, one cut from a brazed SM-1 dummy fuel element and the other from a TIG Welded SM-2 reference element. The test specimens were subjected to transverse temperature differences of up to 200°F, and distortion and strain at various locations were measured. The effect of the thermal stress was to increase the amplitude of original distortions. Additional distortions due to thermal stress were proportional to temperature differential and to ripple length. Tensile stresses in the side plate sections were measured as approximately 10,000 psi at maximum reactor temperature difference. Individual weld loadings in shear were measured as 38 lb per weld. Results of the tests were considered inconclusive because of unrepresentative initial plate distortion. (M.C.G.)

**17594 APAE-Memo-250**

Alco Products, Inc., Schenectady, N. Y.

SM-2 REACTOR CORE AND VESSEL REVIEW REPORT

[FOR PERIOD] DECEMBER 15, 1959 TO MARCH 18, 1960. H. L. Hoover. Mar. 30, 1960. 145p. Contract AT(30-3)-326. OTS.

With this is bound: Battelle Memorial Inst., Columbus, Ohio. SM-2 CORE MATERIALS DEVELOPMENT PROGRAM. Mar. 11, 1960.

The SM-2 core lifetime was calculated and stuck rod criteria formulated. The control system could shutdown the core under the most adverse conditions with any single rod stuck out. The one-half-inch  $\text{Eu}_2\text{O}_3$  flux suppressors adequately suppressed the power spike at the bottom of the core. The nuclear effects of increasing the dimensions of the fuel matrix were calculated. A new analysis of various reactivity measurements performed during the SM-2 critical experiments was made to test the validity of the calculational modes. Two-dimensional temperature distributions for the stainless steel vessel shell and flange and for the SM-2 control rod plates were plotted. The loss of flow experiment was completed on the SM-1 at Fort Belvoir, and the results agreed with analytical predictions. The SM-2 fuel element, control rod, core support structure, and vessel designs were completed. Three steel mills indicated they could supply low cobalt, low tantalum type 347 stainless steel. Corrosion testing of irradiated boron-stainless steel was reactivated. Corrosion and impact testing of nut and bolting materials was scheduled. Dysprosium oxide was considered as an alternate absorber material. Two modified SM-2 fuel assemblies were fabricated for testing in the Westinghouse Test Reactor loop, and two fuel elements were fabricated for insertion in the SM-1 core. Work on controlled addition of a burnable poison, such as  $\text{ZrB}_2$ , in fuel plates was continued. Procedures for welding fuel plates to side plates were completed. Automatic weld sequence timing was adopted for improving product quality. Pressure losses through the complete flow circuit in the reactor were recalculated and the pressure drop analysis brought up to date. Good flow distribution in the control rod fuel element was obtained in a single element rig. Methods of temperature regulation and corrosion control were established. Extended SM-2 critical experiments were initiated. Core support design modifications necessary for an accurate flow divider mockup were completed. Effects of flux suppression upon reactivity and neutron flux at the bottom of the core were measured. Gamma dose rates were measured over the core support plate and along the control rod basket guide. Prototype testing of the control rod drive mechanism was started. The blocked channel method of measuring fuel element internal temperature in SM-2 Core I instrumental fuel assembly was selected as the reference design. (M.C.G.)

**17595 BAW-1135**

Babcock and Wilcox Co. Atomic Energy Div., Lynchburg, Va.

LIQUID METAL FUEL REACTOR EXPERIMENT QUARTERLY TECHNICAL REPORT [FOR] OCTOBER-DECEMBER 1958. 141p. Contract AT(30-1)-1940. OTS.

Results of parametric calculations based on the established core design are given as graphs of  $K_{eff}$  vs. core height; void fraction; absorption cross sections for  $\text{U}^{235}$ , Bi, and graphite; Bi volume fraction in core and end reflector; and end reflector poison; multiplication constant vs. plenum thickness; ring worth of 8  $\text{B}_4\text{C}$  rods vs. position in end reflector; critical Pu concentration vs. enrichment; and Th to U ratio criticality vs. fuel concentration. Brief reports are given of thermal and nuclear analysis and in-

strument and control development. The various LMFRE systems are described including primary coolant, intermediate coolant, heat rejection, electrical, ventilation, fuel addition and sampling, and waste disposal. The flying-rope bridge crane which has motors and gear train drives mounted stationary, not on the bridge, is described. Analytical procedures to detect impurities and minor constituents in bismuth are still under development. A suitable method of analysis for ETR samples is being emphasized and closely correlated with personnel from the NRTS Chemical Processing Plant. Chemical solvents used for decontamination have been checked for corrosive attack on Croloy 2 $\frac{1}{4}$ . The corrosion rates appear satisfactory, being comparable to rates obtained using commercial acid-cleaning techniques. Slurry work has confirmed the reduction of UO<sub>2</sub> by Zr, but no measurable reduction occurred in homogeneous thorium-urania particles. Work on reduction of uranium carbides and fluorides is also underway, in addition to wetting angle studies. Additional study of fuel solutions by metallurgical techniques has shown that uranium is not entirely in solution at the power operating temperatures; instead, it is present as extremely small particles. Work on diaphragms, thermocouples, pressure indicators, level indicators, and flowmeters is underway. An electrical analog is being used in the study of electromagnetic flowmeters. The 2 $\frac{1}{2}$ -in. test loop was completed; operation will begin after the level indicators and other test components are installed. A 10-gpm electromagnetic pump is being developed. Testing of a prototype bismuth pump in a 6-in. test loop was halted at request of the Atomic Energy Commission. The drybox and the glovebox were constructed to provide necessary facilities for beryllium welding. Preliminary welds were made in beryllium tubing to form a closed end "thimble." Investigation of brazing was begun. Several techniques were used to weld and braze molybdenum. Croloy 2 $\frac{1}{4}$  in small pipe sizes were induction welded. All of these projects showed encouraging results. The operation of dynamic pump test loops continued; some Croloy materials tests with the higher zirconium concentrations indicate satisfactory corrosion resistance. The tilting capsule tests indicate much greater corrosion and metal transport at 975°F but are beginning to show some advantage for Croloy 1 $\frac{1}{4}$ . Several stress-rupture tests in a bismuth atmosphere were operating for over a year with very satisfactory results. Tensile, compressive, and shear strength testing of cemented graphite joints indicates that the joints are almost as strong as the base material. Tests on various graphite impregnants are reported. Preliminary absorption data and some density data are reported for various types of graphite. Physical and mechanical properties of graphite are being determined. Modulus of elasticity and flexural strength are also being determined. (For preceding period see BAW-1125.) (T.R.H.)

**17596 DP-485**

Du Pont de Nemours (E. I.) & Co. Savannah River Lab., Aiken, S. C.  
HEAVY WATER MODERATED POWER REACTORS. Progress Report [for] March 1960. R. R. Hood, comp. Apr. 1960. 35p. Contract AT(07-2)-1. OTS.

Safeguards analyses of the boiling D<sub>2</sub>O loop of the Heavy Water Components Test Reactor (HWCTR) show that neither a power failure nor a loss of cooling water will cause a serious accident if the reactor is scrammed. Construction was started on a full-scale mockup of the bayonet for this loop. The mockup will be used for studies of possible vibration phenomena associated with the flow of steam-water mixtures. Emphasis in the development of uranium metal fuel for power reactor use has been shifted to coex-

truded tubes that have a higher surface-to-volume ratio than those fabricated heretofore. The modified tube design will permit higher powers to be achieved without exceeding thermal limitations, and offers the potential advantage of improved metallurgical behavior during irradiation. A swaged tube of uranium oxide with stainless steel cladding apparently failed during irradiation. (auth)

**17597 IDO-28548**

Aerojet-General Nucleonics, San Ramon, Calif.

ARMY GAS-COOLED REACTOR SYSTEMS PROGRAM. Monthly Progress Report for November 1959. Dec. 31, 1959. 57p. Contract AT(10-1)-880. OTS.

Check-out and run-in of the utility and process systems of the Gas Cooled Reactor Experiment I were essentially completed. Proof tests of the main coolant loop and the reactor were unsatisfactory due to leakage at reference conditions. The BMI-16 blowers for the GCR were modified and tested. An IBM code was developed for heat transfer calculations on fuel elements. Water flow tests were performed on several fuel element models with an airfoil, spiral wire, and bearing spacers. The wire spacer gave the most favorable pressure drop under ML-1 reference conditions. The 2500 hr Hastelloy X specimen, exposed to air corrosion, showed a maximum of 0.003 in. of intergranular oxidation. Hot cell examination of the IB-1 $\beta$ T fuel element revealed that the source of leakage was the braze joint sealing the thermocouple sheath in the top plug of the fuel pin. Fabrication of the IB-2T and IB-2 $\phi$ T test elements was continued. A solid-moderated, homogeneous GCRE-II was the back-up system to the heterogeneous, water-moderated reactor in the AGCRSP. A materials program screened and proof-tested fuel moderator bodies, coatings, and can materials. In-pile capsules were fabricated and one was irradiated. Design of a field-prototype power generating unit was 90% completed. Fuel material for the ML-1B critical assembly was shipped to Nuclear Conversion and Equipment Corp. for conversion of UF<sub>6</sub> to UO<sub>2</sub>. Installation of equipment and piping was completed for open cycle testing of the Gas Turbine Test Facility. The open cycle components were checked out for operation with the exception of final system check. (M.C.G.)

**17598 KAPL-M-SSD-54(Rev. 0)**

Knolls Atomic Power Lab., Schenectady, N. Y.

SYSTEM DESIGN DESCRIPTION AND OPERATING INSTRUCTIONS FOR THE S3G COOLANT ACTIVITY TEST FACILITY. J. W. Sapp. Aug. 7, 1959. 27p. Contract W-31-109-Eng-52. OTS.

A design description and the operational procedures are given for the S3G coolant activity test facility, a facility to measure primary coolant activity at various power levels and after shutdown and rate of reactivity buildup. (C.J.G.)

**17599 MND-LFBR-2304**

Martin Co. Nuclear Div., Baltimore.

LIQUID FLUIDIZED BED REACTOR STUDY SECOND QUARTERLY PROGRESS REPORT, FEBRUARY 1 TO APRIL 30, 1960. May 1960. 50p. Contract AT(30-1)-2460. OTS.

The selection of the full critical was made as the experiment to be used to investigate the stability of the fluidized bed reactor. Work was continued on the design and planning of the critical experiment and major equipment was ordered for the critical loop. The high-pressure test loop is undergoing shakedown operation. The construction, instrument calibration, and hydrostatic tests were completed. Investigations of the effects of additives, pellet shapes, cladding variables, and fabrication processes are discussed. Screening tests in the

Gall mills, autoclaves, and low-temperature loops continued to obtain experimental results of the various pellet abrasion samples. (For preceding period see MND-LFBR-2303.) (W.D.M.)

**17600 MND-M-1814**

Martin Co., Nuclear Div., Baltimore.

PM-1 NUCLEAR POWER PLANT PROGRAM 3RD QUARTERLY PROGRESS REPORT FOR SEPTEMBER 1 TO NOVEMBER 30, 1959. E. H. Smith and J. S. Sieg. Mar. 1960. 358p. Contract AT(30-1)-2345. OTS.

A description is presented of work on the design, development, fabrication, installation, and initial testing and operation of a prepackaged air-transportable pressurized water reactor nuclear power plant, the PM-1. The specified output is 1 Mw(e) and 7 million Btu/hr of heat. The plant is to be operational by March 1962. The principal efforts during the third quarter were the furthering of the final design and preparation of specifications for some long-lead components. The entire power plant was divided, for final design purposes, into 37 subsystems. The status of work on each subsystem is reported. A revised summary of design parameters is given, with flow diagrams of the primary and secondary systems. The most significant changes were in core design details and in the packaging and housing plan. A scheme for integral housing using the shipping containers for structural components was dropped, except for the decontamination package. Systems development work included preparations for full-scale structural testing of a test package, completion of the survey of in-core instrumentation techniques, completion of development work on the reactor control and instrumentation system, and further development of components for the steam generator, condenser, and turbine generator which are not available commercially. The conclusions of the in-core and control instrumentation work are summarized briefly. Reactor development work included: (1) Preparations for the flexible zero-power test (PMZ-1) program. (2) Preparations for the revised fuel element irradiation test program. (3) Continuation of reactor flow tests. (4) Further work on the heat transfer test program, including evaluation and reporting of the seven-tube test section tests (SETCH-1) and design of a follow-up program and unit (SETCH-2). (5) Completion of the single-tube test section program (STTS-2) and design of the follow-up STTS-3 and STTS-4 programs. (6) Further work on the development and testing of magnetic jack-type control rod actuators. Core fabrication commenced with delivery of the first batch of  $UO_2$  and pilot runs of fuel element fabrication. Ultrasonic testing of selected pilot run fuel tubes was conducted. Work continued on study of control rod materials,  $UO_2$  recovery techniques, and boron analysis. (For preceding period see MND-M-1813.) (auth)

**17601 ORNL-1556(Del.)**

Oak Ridge National Lab., Tenn.

AIRCRAFT NUCLEAR PROPULSION PROJECT QUARTERLY PROGRESS REPORT FOR PERIOD ENDING JUNE 10, 1953. W. B. Cottrell, ed. July 24, 1953. Decl. with deletions Oct. 28, 1959. 106p. Contract W-7405-eng-26. OTS.

The technical progress of the research on the circulating fuel reactor and other ANP research at ORNL is recorded. The nucleus of the effort on circulating fuel reactors is centered upon the Aircraft Reactor Experiment, a 3-Mw high-temperature prototype of a circulating fuel reactor for the propulsion of aircraft. The experiment is being assembled, and its status is summarized. Other research areas reported on include experimental reactor engineering, reactor physics, reflector-moderated

reactor critical experiments, chemistry of high-temperature liquids, corrosion research, metallurgy and ceramics, heat transfer and physical properties, radiation damage, analytical studies of reactor materials, fluoride fuel reprocessing, Lid Tank Facility, and Tower Shielding Facility. (For preceding period see ORNL-1515.) (W.D.M.)

**17602 TID-5941**

Duquesne Light Co., Shippingport, Penna.

LOSS OF LOAD TESTS, CORE I, SEED 1. Test Results DLCS-1670102 (T-554925). First issue, May 4, 1960. 37p. OTS.

An investigation was conducted to determine the ability of the PWR plant and controlled steam relief system to handle both partial and complete losses of load. The reactor plant was able to handle both partial and complete load losses when the rate of load decrease was limited to approximately 0.7 Mw/sec with the controlled steam relief system in service. The reactor plant was also able to handle all but the maximum load decrease of 63.5 Mw under the same conditions with the pressurizer spray in the closed position. (J.R.D.)

**17603 TID-5942**

Duquesne Light Co., Shippingport, Penna.

REACTOR PLANT CONTAINER INTEGRITY TEST, CORE I, SEED 2. Test Results DLCS-3570201 (T-643733). First issue, May 25, 1960. 6p. OTS.

Tests were conducted to prove the integrity of the 48-inch butterfly valves in the PWR reactor plant by means of air pressure, visual inspection, and operating check. The leak rate on 1A and 1B exhaust valves was 4.1 psi/hr, while the rate on the 1C and 1D supply valves was 5.6 psi/hr. These leak rates were deemed acceptable by the Atomic Energy Commission. (J.R.D.)

**17604 TID-5943**

Duquesne Light Co., Shippingport, Penna.

RADIATION LEVELS IN THE VICINITY OF THE PURIFICATION DEMINERALIZERS. SECTION I. FOURTH PERFORMANCE, 4947 EFPH. Test Results DL-S-234 (T-641306). First issue, Oct. 15, 1959. 11p. OTS.

Tests were conducted to measure the extent of activity build up outside the 1 AC purification demineralizer vessel inside the PWR concrete enclosures. Data obtained in this, the fourth test, indicate that a band of relatively high radiation level exists near the middle of the demineralizer vessel. It was concluded that no conclusive estimate of the resin life span can be made using the first four tests as a basis. (J.R.D.)

**17605 TID-5960**

Duquesne Light Co., Shippingport, Penna.

PERIODIC RADIATION SURVEY OF REACTOR PLANT CONTAINER AND COMPONENTS AFTER SHUTDOWN, "G" SURVEY. 5532.3 EFPH. CORE I, SEED 1. Test Results DLCS 1840502 (T-612076). First issue, May 2, 1960. 15p. OTS.

A survey was made to measure the radiation level and its decrease at expected hot spots in the PWR reactor chamber and pressurizer compartment after shutdown at 5532.3 EFPH. (J.R.D.)

**17606 TID-5961**

Duquesne Light Co., Shippingport, Penna.

DETERMINATION OF BLOW-OFF TANK VENT THROTTLE VALVE OPERATING CHARACTERISTICS. SECTION I. Test Results DL-S-303 (RNI-37). [Oct. 1959]. 5p. OTS.

Studies were made to develop a curve of control air operating pressure versus valve stem movement for RWD

system throttle valve (blow-off tank vent throttle valve). Resulting data are tabulated. (J.R.D.)

**17607 TID-5962**

Duquesne Light Co., Shippingport, Penna.

PERIODIC RADIATION SURVEY OF REACTOR PLANT CONTAINER AND COMPONENTS AFTER SHUTDOWN "E" SURVEY. CORE I, SEED 1. TEST RESULTS DLCS-1840303 (T-612076). [May 1960]. 10p. OTS.

An investigation was conducted to determine the effects of isolation and forced draining on the radiation level of the PWR 1AC hairpin loop and to determine, by chemical analysis, the extent of the activity in the horizontal and vertical legs (U-bend) of the loop piping. Data are presented in a plot of radiation level versus time after shutdown. Other data are tabulated on activity levels in the loop at various intervals for 12 hours after draining. (J.R.D.)

**17608 TID-5963**

Duquesne Light Co., Shippingport, Penna.

EXAMINATION OF COMPONENTS FOR CRUD AND CORROSION (PRESSURIZER HEATERS AND HEATER WELLS) CORE I, SEED 1. Test Results DLCS-1550104 (T-612080). First issue, May 4, 1960. 6p. OTS.

An examination was conducted to observe the extent and location of corrosion, crud deposits, and defects in components of the PWR plant. Smear samples were obtained from the heater elements. The radioactive nuclides found include  $\text{Co}^{60}$ ,  $\text{Fe}^{59}$ ,  $\text{Mn}^{54}$ ,  $\text{Cr}^{51}$ ,  $\text{Hf}^{181}$ , and  $\text{Zr}^{95}$ . No defects, serious distortions, or excessive crud buildup were found. (J.R.D.)

**17609 TID-5964**

Duquesne Light Co., Shippingport, Penna.

CORE I CONTROL ROD DRIVE MECHANISMS PERIODIC TESTS, ADDENDUM I. CORE I, SEED 1. Test Results DLCS-1480101 (T-550011). First issue, May 2, 1960. 10p. OTS.

Tests were conducted to determine if each control rod drive mechanism operates properly. It was found that all control rod drive mechanisms operated satisfactorily except No. 83 which dropped during the mechanism rotation test. No other operating characteristic changes were noted. (J.R.D.)

**17610 TID-5965**

Duquesne Light Co., Shippingport, Penna.

REACTIVITY LIFETIME 3813.0 TO 4948.0 EFPH, CORE I, SEED 1. Test Results DLCS-2250104 (T-612118A). First issue, Apr. 9, 1960. 205p. OTS.

Tests were conducted to determine the performance characteristics, reliability, stability, and lifetime variations of the PWR station and core under normal, steady state conditions at approximately 60 Mw(e) net output. The station was test operated at approximately 60 Mw(e) for 1,135 hours. Data obtained in the test are discussed and tabulated. Normal operation is also discussed along with incidents and scheduled shutdowns which occurred. (J.R.D.)

**17611**

INCREASED EFFICIENCY OF GAS-COOLED POWER REACTORS. T. Kh. Margulova and L. S. Sterman. Atomnaya Energiya 8, 448-51(1960) May. (In Russian)

The maximum efficiency curves as a function of vapor pressure in high-pressure coolant loops in a power plant operating with two-pressure cycles at a coolant (gas) temperature of 375°C are plotted and analyzed. A comparison is made of superheated and non-superheated plants. (R.V.J.)

**17612**

WHAT DOES NUCLEAR FUEL COST? A COMPARATIVE STUDY ON THE FUEL CYCLE COSTS OF POWER RE-

ACTORS. Wolfgang Finke. Atomwirtschaft 5, 204-8(1960) May. (In German)

The total cost of nuclear fuel consists of the cost of the consumed fuel, cost for fabrication, cost for the transportation of the irradiated fuel, processing costs of the irradiated fuel, and inventory costs. These total costs were compared for 200-Mev power reactors of the PWR/BWR, CANDU, and Calder Hall types. The results were \$327.62/kg U or 4.89 mils/kwh for the PWR/BWR, \$95.17/kg U or 3.08 mils/kwh for the CANDU, and \$68.77/kg U or 3.43 mils/kwh for the Calder Hall. (J.S.R.)

**17613**

LATINA—THE FIRST NUCLEAR POWER PLANT IN ITALY. 1. FROM BRADWELL TO LATINA. J. Armor ([Nuclear Power Plant Co., Ltd.], Knutsford, Ches., Eng.). 2. CONSTRUCTION ASPECTS. R. B. Hyde ([Nuclear Power Plant Co., Ltd.], Knutsford, Ches., Eng.). 3. BIOLOGICAL SHIELDING. P. R. Pinnock ([Nuclear Power Plant Co.], Ltd., Knutsford, Ches., Eng.). 4. CONTROL SYSTEM. J. O. Joss ([Nuclear Power Plant Co., Ltd.], Knutsford, Ches., Eng.). Atomwirtschaft 5, 209-16(1960) May. (In German)

The Latina, the first nuclear power plant in Italy, is a direct development of the Calder Hall Reactor at Bradwell. The electrical power was increased from 150 to 200 Mw with no change in the core dimensions but with various individual improvement such as thicker pressure vessel and greater diameter of the gas pipes. The development of the power plant is considered from the viewpoint of the construction, biological shielding, and control systems. (J.S.R.)

**17614**

A UNIFORM METHOD FOR COMPUTING THE POWER COSTS OF VARIOUS TYPES OF NUCLEAR POWER PLANTS. Mihály Ócsai (Power Plant Designing Bureau, [Budapest]) and Imre Búki (Technical Univ., Budapest). Energia es Atomtech. 13, 124-34(1960) Mar. (In Hungarian)

The Hungarian method of estimating the cost indices of new thermal power plants and its application to nuclear power plants are analyzed. Assuming Hungarian conditions of operation, the method is used to compute and compare the cost indices of various foreign nuclear power reactors (Bradwell, Hunterston, the French EDF-1, the GCR-2, Yankee, Dresden, and the Canadian NPD-200). The costs are in Hungarian currency, at given rates of exchange. The data are compiled from the IAEA's 1959 Reactor Catalogue and the proceedings of the Second Geneva Conference. The Anglo-American method of computing the cost per kwh is criticized in that it is convenient with regard to comparability but is based on the assumption of a single central station supplying new consumers. This assumption distorts the results in favor of nuclear power. The Hungarian method is recommended because it takes into consideration the complex interrelation of the power grid to which the new nuclear power plant will be connected. (JPRS)

**17615**

ADVANCED GAS-COOLED REACTOR AT WINDSCALE. [PART] I. Engineer 209, 966-70(1960) June 10.

This reactor is a logical development of advanced power reactors originating from the Calder Hall design. It is designed to serve as a prototype for future power station reactors. The AGCR has a thermal rating of 100 Mw (27.3 Mw(e)). Beryllium-canned  $\text{UO}_2$  fuel elements comprise 80% of the charge, while stainless steel clad elements make up the remainder. The installation provides breakdown and inspection of irradiated fuel. Supporting and complementary experiments at Windscale include sub-

critical assemblies and "HERO," a hot experimental reactor of zero energy. Design characteristics are given for the reactor which is expected to be operable in October 1961. (B.O.G.)

17616

**THERMAL CYCLE OF NUCLEAR POWER STATIONS WITH GAS-COOLED REACTORS [PART II].** J. Juza (Lenin's Plant, Plzen, Czechoslovakia). Jaderná energie 6, 150-4(1960). (In Czech.)

For nuclear power stations using gas cooling in the primary cycle and water vapor in the secondary cycle, the optimum parameters for thermal cycles with two and three vapor pressure stages were determined. The calculations were made for exit gas temperature at 400 to 600°C. (auth)

17617

**AUTOMATIC PROTECTION FOR A GAS COOLED REACTOR.** B. E. Elthan and M. J. Cowper (United Kingdom Atomic Energy Authority, Risley, Lancs, Eng.). Nuclear Eng. 5, 243-4(1960) June.

A scheme for automatic safety control of a gas-cooled reactor is presented. Among the topics discussed are thermocouples, fuel element temperature control, asymmetrical thermal flux measurements, pressure measurements, flow measurement and regulation, and protective logic (arrangement of protective system sensors). Since no component of the protective system can be guaranteed to fail safe, three lines must be installed (three sensors per trip parameter). It is emphasized that the operator should not be placed in any function in the protective system, but simply be in position to take long-term corrective action. (D.L.C.)

17618

**BETA: DANATOM'S 175 MW DESIGN STUDY.** Nuclear Eng. 5, 264-5(1960) June.

The design study for a 175-Mwe, 574-Mwh gas-cooled nuclear power station, BETA, has been published by the Danish Association for Industrial Development of Atomic Energy. It is a natural uranium station with one reactor, 6 heat exchangers, 2 turbine sets, and 150 control rods of stainless steel with 2% boron. Among the features described are its core, pressure vessel, blowers, steam plant, and charge/discharge arrangements. (D.L.C.)

17619

**STEAM CONDITIONS FOR MARINE ORGANIC MODERATED REACTORS.** P. R. Bolt (Hawker-Siddeley Nuclear Power Co., Ltd., Manchester, Lancs, Eng.). Nuclear Power 5, No. 50, 97-9(1960) June.

The economic and thermodynamic aspects of seven different steam cycles for organic moderated marine reactors are reviewed. (auth)

17620

**THE DIRECT GENERATION OF ELECTRICITY. [PART]** 1. B. C. Lindley (C. A. Parsons and Co., Newcastle-upon-Tyne, Eng.). Nuclear Power 5, No. 50, 100-3(1960) June.

Sources of power used at present are discussed, and direct conversion of thermal energy into electricity is concluded to be feasible because of reduced costs. Direct conversion may be accomplished by a thermoelectric generator (assembly of solid semiconductor thermocouples) and by a thermionic generator in which electron emission from cathode to anode occurs. Equations are derived for the thermal efficiencies of the two generators, and graphs are given for the efficiency vs temperature for various arrangements of thermoelectric generators with reactors. It is concluded that the only systems worthy of further

study are the reactors with thermoelectric or thermionic fuel elements. (D.L.C.)

17621

**THE ENGINEERING DESIGN OF POWER REACTORS.** Nunzio J. Palladino (Pennsylvania State Univ., University Park) and Harold L. Davis. Nucleonics 18, No. 6, 85(1960) June.

An outline of the process of designing power reactors is presented. The design progresses through four stages: conceptual design, reference design, revised reference design, and final design. The roles of four men in the design process are discussed: the project manager, reactor physicist, thermal engineer, and mechanical engineer. Associated tasks, e.g., parametric studies, temperature flattening, and transient studies, are also studied. Design criteria (nuclear, thermal, and mechanical) are given, and as an example the evolution of the core design of the Hallam Power Reactor is given. (D.L.C.)

17622

**FIRST TREAT RESULTS—MELTDOWN TESTS OF EBR-2 FUEL.** Edmund S. Sowa (Argonne National Lab., Ill.). Nucleonics 18, No. 6, 122-4(1960) June.

In order to study the meltdown behavior of EBR-2 fuel elements under power surges, single EBR-2 fuel pins were exposed to transients in the TREAT reactor. In normal operation, the clad-metal interface will operate around 540°C; in the meltdown tests, temperatures varied from 970 to 1030°C. Damage commences in the range 970 to 1015°C by penetration of the cladding close to the base and ejection of U through this penetration. Above 1015°C, failure is more drastic with ejection and desposition of U on the graphite mount. (D.L.C.)

17623

**NUCLEAR FLIGHT.** The United States Air Force Programs for Atomic Jets, Missiles, and Rockets. Kenneth F. Gantz, ed. New York, Duell, Sloan and Pearce, [1960]. 220p. \$4.00.

A description is given of the developments in the nuclear propulsion of aircraft, missiles, and space rockets. These developments are a basic step toward future aerospace forces capable of extreme duration of flight, large payload, and flexible maneuver. Power reactors, reactor materials, heat transfer and coolant systems, and power production from nuclear energy are discussed. The development of direct-cycle and indirect-cycle propulsion, ramjet reactors, radioisotope power sources, and radiation effects is considered. (B.O.G.)

## Production Reactors

17624 HW-57252(Rev. 2)

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

**NPR WATER QUALITY DESIGN BASES—REVISION 2 (MIXED PRIMARY SYSTEM).** W. D. Bainard. June 19, 1959. 10p. Contract AT(45-1)-1350. OTS.

The water quality limits, to be used in the design bases for various new Production Reactor systems are discussed. The maintenance of the water quality specifications such as pH, undissolved solids, total solids, chloride, hydrogen, oxygen, and other dissolved gases is discussed. (C.J.G.)

17625 HW-60991

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

**A REPORT ON DISSOLVED O<sub>2</sub> IN THE PRIMARY**

COOLANT OF THE KER LOOPS. L. M. Eikum. Apr. 15, 1959. 30p. Contract W-31-109-Eng-52. OTS.

A series of tests was conducted in an attempt to reduce the observed O<sub>2</sub> content of primary recirculation loop water to a value of < 0.14 ppm by the current loop method which is a combination of pressurizer degasification and venting flow. Test results show the O<sub>2</sub> content of the loops was reduced to a value below < 0.14 ppm shortly after a degasifying flow was started and remained at a value of < 0.005 ppm during most of the test runs. In addition it was determined that the degasifying flow could be stopped after the O<sub>2</sub> content of the loop water was reduced to 0.005 ppm and O<sub>2</sub> content would remain at approximately this level for the remainder of the test. Improved sampling procedure and sample handling developed during the test eliminated erratic results which were common with previous procedures. (auth)

## Research Reactors

### 17626 AERE-M-608

United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England.

NEUTRON FLUX MEASUREMENTS ON AN ALUMINUM PANEL, IN THE POOL AND IN A NATURAL URANIUM GRAPHITE STACK ON LIDO. E. D. Jones. Feb. 1960. 29p. BIS.

### 17627 TID-5906

Lockheed Nuclear Products, Marietta, Ga.

NUCLEAR TRAINING REACTOR FOR THE AEC REACTOR TOUR. Preliminary Report and Hazards Analysis. Feb. 1960. 72p., 3 illus. Contract AT(49-9)-1777. (NR-87). OTS.

The operation, installation, and use of the 10-kw Training Reactor for the AEC South American exhibit to be held in Argentina, Brazil, Venezuela, and Peru are described. The reactor, a special adaptation of the Ohio State University Reactor, is easily portable and extremely safe under the most adverse operating conditions. A brief summary of meteorological and geographical features of the four exhibit locations and an operational program for a select list of experiments are given. (W.D.M.)

### 17628

THE FAST RESEARCH REACTOR BR-2. A. I. Leipunskii (Leipunskij), D. I. Blokhintsev (Blochincev), I. N. Aristarkhov (Aristarchov), I. I. Bondarenko, O. D. Kazachkovskii (Kazackovskij), M. S. Pinkhasik (Pinchaskik), Yu. Ya. Stavisskii (J. J. Smaivisskij), E. A. Stumbur, F. I. Ukrainsksev (Ukraincev), and L. N. Usachev (Usacev). *Kernenergie* 1, 245-7(1958) Apr. (In German)

A brief description is given of the fast research reactor now in operation and its principal experimental and auxiliary equipment. The reactor is used for physical studies with fast neutrons. The core is made up of Pu rods; the lateral reflector is of enriched U. Heat is removed from the core by Hg and from the V reflector by air. The nominal total power capacity of the reactor is 150 kw, of which ~100 kw is generated in the core. (tr-auth)

### 17629

Hahn-Meitner-Institut für Kernforschung Berlin.

RADIOLOGICAL PROBLEMS OF THE OPERATION OF SMALL RESEARCH REACTORS. W. Jacobi. p.237-46 of "Health Physics in Nuclear Installations Symposium, Risø, May 25-28, 1959." (In English)

Radiological problems of operating at 50-kw solution-

type reactor such as the Berlin Research Reactor (BER) are considered. Experimental possibilities and the accompanying radiation hazards are given. The precautions taken to facilitate the control of contamination and the containment of fission products are discussed. Conclusions are given in regard to environmental radiation hazards in the event of a simultaneous leakage of primary and secondary enclosures. (B.O.G.)

### 17630

Reaktor A. G., Würenlingen, Switzerland.

AIR POLLUTION OBSERVED AT THE SWIMMING-POOL REACTOR "SAPHIR." R. Berner, W. Hunzinger, and T. Hürlimann. p.247-51 of "Health Physics in Nuclear Installations Symposium, Risø, May 25-28, 1959." (In English)

During and after operation of the reactor at 1 Mw, air samples were taken to determine the extent of air pollution caused by krypton and xenon, which readily escape from the pool water to the surrounding air. From the known number of fissions delivering their fission products to the water and the various time constants involved, the concentrations of Rb<sup>88</sup>, Rb<sup>89</sup>, Sr<sup>89</sup>, and Cs<sup>138</sup> in the air are explained quantitatively. The escape constant from water to air is seen to hold for krypton as well as for xenon. An estimate of the contribution to air pollution may be calculated for the isotopes descending from krypton and xenon which lie beyond the detection limit. (B.O.G.)

## WASTE DISPOSAL AND PROCESSING

### 17631 HW-32978

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

ADSORPTION OF RADIOACTIVE ISOTOPES BY SOIL FROM A BISMUTH PHOSPHATE WASTE. D. W. Rhodes, K. R. Holtzinger, and J. R. McHenry. Sept. 1, 1954. Decl. Mar. 24, 1960. 14p. Contract W-31-109-Eng-52. OTS.

Data obtained from laboratory experiments indicated that Ru from the 112-T bismuth phosphate waste solution penetrated to a greater depth in soil than any of the other radioactive isotopes. Cesium penetrated to a lesser depth than Ru, and the other radioactive isotopes followed some distance behind Cs. Application of the laboratory results to the 241-T crib area indicated that Cs probably penetrated to a depth slightly greater than 80 ft and that Ru should have moved beyond this point, possibly to ground water. Analyses of water samples from wells near the crib area indicated that the depth of penetration of the radioactive isotopes was approximately as predicted on the basis of the experimental results. (auth)

### 17632 HW-36425

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

POTENTIAL NITRATE DECOMPOSITION-HIGH LEVEL WASTE STORAGE. C. R. Anderson. Apr. 27, 1955. Decl. Apr. 28, 1960. 4p. Contract [W-31-109-Eng-52]. OTS.

It is suggested that the decomposition of nitrate salts in Purex and Redox high level wastes due to high activity levels could introduce hazards which offset the economic gain of reduced storage volumes obtained by self concentration. It is recommended that self-concentration of Purex wastes should not be started until further studies are completed. (C.H.)

**17633** HW-42699

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

## ADSORPTION BY SOIL OF STRONTIUM FROM 216-S

CRIB WASTE. D. W. Rhodes. Feb. 15, 1956. Decl.

Mar. 28, 1960. 7p. Contract W-31-109-Eng-52. OTS.

Soil equilibrium adsorption experiments with D-1 waste (cell drainage) and D-2 waste (process condensate) from Redox Plant indicated that >90% of the cesium was readily adsorbed by soil from these wastes, but that <10% of the strontium was adsorbed under present disposal conditions. The data further indicated that the relatively poor adsorption of strontium was due to the low pH of both the D-1 and D-2 wastes, and also was affected by the dissolved salts in the D-1 waste. The addition of a base to raise the pH to approximately pH 8 to 10 increased the adsorption of strontium to >90% from the D-2 and from a 1:60 mixture of the D-1-D-2 wastes. The addition of a phosphate salt as well as a base was necessary to obtain a similar increase in the adsorption of strontium from the D-1 waste alone. (auth)

**17634** HW-54599

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

A HISTORY AND DISCUSSION OF SPECIFIC RETENTION  
DISPOSAL OF RADIOACTIVE LIQUID WASTES IN THE 200  
AREAS. W. A. Haney and J. F. Honstead. Apr. 18, 1958.  
Decl. Apr. 28, 1960. 12p. Contract W-31-109-Eng-52.  
OTS.

Specific retention is defined at Hanford as that volume of water that may be disposed to the soil and be held against the force of gravity by the surface tension characteristics of the soil surfaces and pores, when expressed as per cent of packed soil volume. A history of this method of disposal at Hanford from 1944 through 1957 is presented, and recommendations for its use are outlined. A value of 6% by volume is recommended for specific retention application until unknowns associated with this disposal method can be more completely evaluated. About 6% by volume is thought to be a conservative value that recognizes the uncertainties resulting from poorly defined physical characteristics and lack of more certain information regarding the mechanism. In addition, continued discrimination against disposing of wastes by this method, even under the more restrictive conditions, is recommended. (C.H.)

**17635** HW-61475

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

FLOW RATE DISTRIBUTION BENEATH A WASTE DIS-  
POSAL SITE. P. P. Rowe. Aug. 3, 1959. 11p. Contract  
W-31-109-Eng-52. OTS.

Two methods of calculating flow-rate distributions beneath a waste disposal site are presented. Data obtained from a two-dimensional percolation model were used to evaluate the two methods. (C.J.G.)

**17636** HW-63414

General Electric Co. Hanford Atomic Products Opera-  
tion, Richland, Wash.

ONCE THROUGH DECONTAMINATION STUDIES—  
INTERIM REPORT NO. 1. Lyle D. Perrigo and J. F.  
Hokenson. Jan. 12, 1960. 9p. Contract AT(45-1)-1350.  
OTS.

Three once-through decontamination tests were per-  
formed on contaminated D reactor pigtails using pro-  
prietary sodium bisulfate and sulfamic acid-ammonium  
fluoride cleaning agents. Two other runs were made on  
contaminated carbon and stainless steel washer-type  
coupons to determine once-through cleaning efficiencies

on high-temperature contaminated films. It was found that a proprietary sulfamic acid-ammonium fluoride compound, Turco 4306-B, effectively reduced pigtail activity to background readings. A corrosion loss of 0.956 mils on Zircaloy-2 coupons was obtained following the Turco 4506-B flush. Good decontamination of a D reactor pigtail was obtained in 24 minutes using a proprietary sodium bisulfate at 10% and 8 gpm, but reduced concentrations and lower flow rates did not give appreciable activity reductions. An oxalic acid com-  
pound greatly reduced activity on KER contaminated carbon steel specimens but had little effect on the ac-  
tivity of KER contaminated stainless steel samples. Wyandotte-1112, a proprietary sodium bisulfate, reduced the activity of both. (M.C.G.)

**17637** IDO-24036

Fluor Corp., Ltd., Los Angeles.

TITLE I REPORT—CPP STACK GAS MONITOR. Mar. 27,  
1959. Changed from OFFICIAL USE ONLY May 23, 1960.  
42p. Contract AT(10-1)-883. OTS.

The design is described of a monitor to continuously record the rate and total emission of radioactivity from the Chemical Processing Plant off-gas stack at the National Reactor Testing Station. The monitor collects and delivers to sensing instruments a representative sample of stack gas and measures and records the activity. This is accomplished by means of a sampling probe and sample loop and by gamma scintillation crystals and the necessary electronics. The monitor provides for continuous deter-  
mination of total gamma activity in stack gas, Iodine-131, the noble gases, and particulate activity by difference. Intermittent determination of the fission product content of the particulate is by means of laboratory analysis of particulate filters. Alarms are provided to alert opera-  
tors to radiation levels dangerous to personnel, high ac-  
tivity in the CPP stack, and non-isokinetic sampling. (C.H.)

**17638**FILTRATION OF THE GASEOUS EFFLUENT OF AN AIR-  
COOLED REACTOR. I. A. Mossop (United Kingdom Atomic  
Energy Authority, Sellafield, Eng.). Brit. Chem. Eng. 5,  
420-4; 426(1960) June.

During the past six years work at Windscale has re-  
sulted in considerable improvements in the performance of filters used in the pile stack effluent. Replacement of starch-bonded stable tissue filter by the coarse fiber type reduced the number of particles escaping for constant effluent conditions by a factor of approximately three. Other types of filters are discussed which helped to reduce this factor. In addition to these obvious advances in filter performance, improvements had been made in other directions. The latest filters were able to hold an increased dust load before replacement became necessary. This extended life of some 20 to 30 weeks should greatly reduce the radiation exposure of personnel handling the disposal of the filters. (B.O.G.)

**17639**Netherlands. Gezondheidsorganisatie, TNO  
A LICENSED RADIOACTIVE WASTE EVACUATION SERV-  
ICE. H. R. Marcuse. p.219-22 of "Health Physics in  
Nuclear Installations Symposium, Risø, May 25-28, 1959."  
(In English)

A collection service is proposed for all spent radioactive substances emitting at certain levels or otherwise repre-  
senting a danger to public health. The need for a service of this type is cited for the Netherlands, where the ground-  
water level is so high that the spread of contamination could not be prevented. The types and quantities of waste avail-  
able and its handling are discussed. (B.O.G.)

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